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The Dock & Harbour Authority

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Editorial Comments

A Notable Sicilian Port.

The long and eventful history of the old world port and harbour of Catania in Sicily, dating back to the pre-Christian Era, which is so fully and interestingly related by Dr. Ing. D'Arrigo in his article in the present issue, undoubtedly contains instructive information which will be of benefit to our readers, many of whom will be able to recall the association of the port with the war-time operations of the Allied Forces when they were forcing a difficult and strenuous passage from Northern Africa to the Mainland of Italy. Together with Palermo, Catania is one of the two leading ports of the Island, and, as such, suffered severely at the hands of the Germans who wrought great havoc before leaving the place. The tale of this havoc, as set out in Dr. Ing. D'Arrigo's narrative, is so appalling that one can feel little surprise at the huge sum which is the estimated cost of repair and reinstatement.

But it has not only been by the hands of man that the harbour of Catania has been assaulted. Nature itself has treated the carefully prepared protective works with violence no less destructive. The elaborately constructed Eastern Mole, designed on what were thought a quarter-of-a-century ago to be impregnable principles, was, in March, 1933, overwhelmed in a storm of unprecedented fury and a considerable portion of it destroyed, thereby undermining the confidence of harbour engineering experts in the stability of monolithic structures founded in depths of 40-ft. of water.

For those of our readers who are interested in the technicalities of this disaster and wish to refresh their memories about the essential details reference may be made to an article on The Stability of Vertical Breakwaters which was published in this Journal in September, 1944 (vol. xxv., p. 106 et seq.). The account therein given of the phenomenal storm showed that the waves attained a height of 7½ metres and a length of 230 metres, the force of impact on the breakwater being such that monolithic blocks of 320 tons apiece were dismantled and wrecked. This storm is comparable with a similar one of slightly greater intensity in the following year which resulted in the collapse at the harbour of Algiers of part of the Mustapha Mole formed of blocks weighing 400 tons.

The Port of Catania has, in fact, had its full share of misfortune and hopes may well be expressed that a brighter future awaits this distinguished and enterprising Sicilian trade centre, which is admirably situated for dealing with an extensive traffic in the Mediterranean. Advantage has been taken of the experience gained in the past to design the new harbour works on sound lines and to equip the port in a manner suitable for its important destiny. When the programme of works now in hand is completed, Catania will be fully qualified to resume its place among the leading ports of Italy.

International Conference on Soil Mechanics.

The notice recently issued to the press, that the Second International Conference on Soil Mechanics and Foundation Engineering is to be held in Rotterdam from the 21st to 30th June, 1948, calls to mind the first Conference which was held at Cambridge, Mass., U.S.A., in 1936. This proved very successful in disseminating knowledge and promoting discussion in a new branch of science which is proving of great value for the solution of difficult foundation problems.

The original intention had been to hold the Second Conference at Rotterdam in 1940, in honour of the opening of the Maas Tunnel, but the war intervened. That the same venue should be chosen so soon after the cessation of hostilities is therefore fitting. It is also an indication of the rapid and vigorous recovery Holland is making from the ravages of war.

It is also appropriate that Professor Karl von Terzaghi, of Harvard University has again been elected President, and will occupy the chair at the second conference, for he has been foremost in establishing the claim of soil mechanics to be a branch of engineering science. The Secretary, Professor A. Casagrande, also has acquired distinction in this field. An organising Committee has been appointed under the chairmanship of Ir. J. P. von Bruggen, with Ir. T. K. Hurzinga, Director of the Laboratory of Soil Mechanics, Delft, as Secretary and Ir. W. C. van Mierlo, Treasurer.

During the decade which has elapsed since the First Conference was held, much additional knowledge has been gained, and the Organising Committee have shown their appreciation of this fact by giving a very broad classification of subjects suitable for papers. These are limited to 2,500 words in length, and must be submitted for consideration not later than 1st January, 1948. Full details can be obtained from the Secretary, The Institution of Civil Engineers, Great George Street, London, S.W.1.

Dock and harbour engineers will find much to interest them in the following topics: stability and movements of soil; stress distributions and settlement of foundations; piled foundations and pile loading tests; methods for improving the mechanical quality of soils and the determination of groundwater movements. No doubt a great deal of useful information will be forthcoming as a

Editorial Comments—continued

result of war-time experience, and some of the lessons learned will be applicable to problems connected with dock and harbour works.

It is to be desired that British engineers will be fully and efficiently represented at the conference seeing that the Building Research Station at Watford was largely concerned in demonstrating the value of investigation into the new science, and the need for its application to the solution of difficult foundation problems.

Indian Coastal Trade.

The third and concluding portion of the Indian Ports Committee's Report, which deals with its third term of reference, will be found in this issue. It is essentially concerned with the problem of the development of coastal trade along the three thousand odd miles of coastline in India, stretching from Karachi to the mouth of the Hooghli. The consideration of this problem falls naturally into two parts, associated respectively with the Malabar and Coromandel Coasts, in which it so happens that the conditions, physical and commercial, are definitely separate and distinct. The Eastern Coast from Calcutta to Tuticorin is characterised in a marked degree by the phenomenon of littoral drift, whereas this is absent, or not particularly noticeable on the Western Coast, although there is a certain amount of periodical silting in harbour approach channels. Again, on the Eastern side, railway tracks run closely alongside, or not far distant from, the coastline, whereas on the Western or Malabar side, South of Bombay, there is no such proximity, the railways lying anything from 50 to 100 miles inland. This is due to the fact that in the Bombay Province there is only a narrow strip of coastal land between the Western Ghats and the sea; the Province of Madras, on the other hand, is bordered by a much broader tract producing a more cultivated and more densely inhabited area.

Considering these diametrically opposite local conditions, the Committee found that the coastal services were accommodated at 75 minor ports in the Bombay Province and 100 in the Madras Province. The most striking feature of the Malabar ports is the passenger traffic, which, at present, seems to be carried on under some disability, as, for instance, at Ratmagiri, where it is stated that the unfortunate passengers, unable to use the landing jetty in rough weather, have occasionally to wade through the sea from the boat to the beach. Such primitive methods certainly call for remedy and the use of landing pontoons is advocated in the Report.

This and other detailed recommendations are worthy of careful study and while their implementation depends upon the view taken by the new Central Administration for India with, it is to be hoped, the co-operation of the Native States, we cannot imagine that findings so carefully considered and so convincingly stated will fail to engage the most earnest attention and approval of the authorities concerned.

The Transport Bill.

After a stormy passage through both Houses of Parliament in the face of strenuous opposition to its progress, the Transport Bill has now been passed through all its stages and has become the law of the land. It is a revolutionary and sweeping enactment, affecting railways, road haulage, London Transport, canals, and their ancillary appendages, including hotels and steamships owned by the respective undertakings. Also, with disquieting lack of definition there are included powers to deal with docks and harbours which are to be "subject to review" and, where deemed expedient, liable to acquisition by the State. It is this last-named feature of the Bill which cannot fail to cause misgivings and apprehensions on the part of many port authorities who are left in doubt as to where they stand. A sword of Damocles hangs suspended over their heads and threatens to jeopardise their arrangements for the future development of their undertakings. How can they with any feeling of confidence embark on schemes of any importance or entertain projects which, however desirable in their opinion, are subject to the uncertainty of government intervention and possible veto? The situation for them is peculiarly unhappy, and indicates a strange reluctance on the part of the Government to make up their minds and disclose their policy (if they have one), in regard to one of the most vital activities of the country, connected as it is with overseas trade and affecting both exports and imports, the former of which the country is urged to expand and the latter to curtail.

Port Authorities and Shipping interests alike have expressed their antipathy to any tampering with the elaborate and complicated systems of port administration which have been evolved in the course of many years to cope with the special needs and requirements of local water-borne trade and which have proved themselves adequate and convenient for the purpose. To destroy, radically alter, or otherwise hamper the existing regime in pursuit of idealistic uniformity would be disastrous.

Meanwhile, the moderate and carefully-considered recommendations put forward by the Dock and Harbour Authorities' Association in response to the invitation of the Minister of Transport made some time ago remain unaccepted and apparently ignored, except in so far as some enigmatic utterances of the Parliamentary Secretary to the Ministry have hinted at the drawing up of schemes of reorganisation by a Port Commission shortly to be formed.

The Severn Bridge.

The issue of an order by the Minister of Transport for the construction of the new bridge over the Severn is a notable event in the history of the river and is bound to have some influence on its navigation, more particularly during the period of construction. It may also be some slight handicap to the Port of Gloucester. The Severn Bridge will be the largest suspension bridge in Europe and the third largest in the world. Only two bridges, both in the United States, have longer centre spans—that of the Golden Gate at San Francisco, 4,200-ft.; and the George Washington Bridge over the Hudson River at New York, 3,500-ft. In addition to the centre span of 3,300-ft., the Severn Bridge will have two side spans, each of about 1,000-ft. The vertical clearance for shipping will be 110-ft. above high water near the towers and about 120-ft. in the centre.

The concrete piers will be about 200-ft. long by 60-ft. wide. The steel towers, which will rest on these piers and support the main cables, will rise to a height of 480-ft. above high water. Each tower will consist of two legs about 30-ft. by 30-ft., braced by panels at roadway level, at the top, and at about 70-ft. above the roadway. Accommodation for road traffic on the bridge will consist of two carriageways, each 24-ft. in width; two cycle tracks, each 9-ft. wide; and two footpaths, each 6-ft. wide.

Before work on the actual construction of the bridge can be started it will be necessary to build a breakwater on the western foreshore of the Estuary for the protection of the workmen and to permit the existing ferry between Aust and Beachley to operate during the construction of the Beachley pier. Tenders for the breakwater will be invited in the near future and its construction will be started in the autumn.

Various measures for the protection of navigation on the Severn during construction of the bridge have been agreed after consultation with the Gloucester Harbour Trustees and other authorities concerned.

The North Sea Ports and the Rhineland.

The deviation to German ports of traffic from the Rhineland, which has for some time materially affected the prosperity of the ports of Antwerp and Rotterdam, is, we understand from a message to the press from New York, about to be remedied in some measure by the approval of the United States authorities in regard to the resumption of the former trade route to and from the British and American zones of occupation in Germany. Hitherto, subsequent to the war, cargo has been passed through the German ports of Hamburg and Bremen from considerations of economy, since occupation marks could be used to pay the charges. It has now been found practicable to utilise the ports of the Low Countries for transhipment, so that sea-destined traffic can revert to its former route. The matter was the subject of comment in our June issue, in which was published the report of the European Central Inland Transport Organisation, reviewing the traffic conditions at the Continental North Sea Ports.

The Port of Catania

A Prominent Sicilian Port*

By DOTT. ING. AGATINO D'ARRIGO, Director of the Port Works.

Historical Notes

THE invasion of the Etna lava flow, reaching in historical times as far as the coastline, the fluvial-marine deposits retained in a supreme degree by the peak ruggedness of the Gulf of Catania, the hydrodynamic action of the sea, more violent here than elsewhere in the Mediterranean, and the vandalistic and careless operations of man have obliterated all but the least traces of the ancient harbour of Catania where, amongst other events, there wintered in 415 B.C. the Athenian Fleet on the occasion of the memorable expedition of Alcibiades into Sicily and where was fought in 405 B.C. the stirring naval action between the Syracusans and the Carthaginians, in which the latter were engaged with not less than 500 vessels of war (Diodorus Siculus, XIV. 50).

Panoramic view of Catania Harbour.

It is not improbable that the ancient harbour of Catania found itself buried in conjunction with the bay comprised between Larmisi and Ognina, overwhelmed in 1381 by the lava of the Crocefisso and of the Rotolo, to which later morfographical features may have been related, also the characteristically accentuated embayment through the juxta-position of the more distant isobaths of the marine depths in front.

Only thus can be explained the existence in the Roman epoch of the broad Virgilian harbour (Aeneid III., 570), with its calm sheet of enclosed water sheltered from tempestuous winds: "Portus ab accessu ventorum immotus et ingens ipse," as also that in the Norman epoch of the "bel porto," mentioned by Edrisi.

We know that in 1287, during the reign of Giacomo d'Aragona, the Admiral Ruggero di Lauria entered the harbour with 40 galleys. A century later the harbour was closed under the direction of Simone del Pozzo, Bishop of Catania.

In the fifteenth century, Alfonso d'Aragona entered the Saracen harbour with his fleet, but finding it much damaged, ordered the construction of a new breakwater in 1434.

Successive attempts to construct a new outer mole were not fortunate, as the works were destroyed by storms.

In 1782, in the reign of Ferdinand III., was begun the execution of a project drawn up by the engineer Castagna, but in 1783 a storm reduced it to a mass of rubble, which constituted the first arm of the mole of the dock Alcala.

In 1785 the conduct of the works was entrusted to the great Maltese mathematician and engineer, Joseph Zahra (1730-1821), professor at the University of Catania, who originated the Old Harbour with an external breakwater of an overall length of 258 metres, which, in 1854, had become a sheltered basin of about 15 hectares.

Zahra designed and executed in the most ancient tradition of the Mediterranean for maritime works, the sub-structure of the outer breakwater with large caisson monoliths without bottoms, filled with pozzuolana concrete deposited accurately on the site, having dimensions of 20.64 metres by 10.32 metres by 9.30 metres, and calculated to resist the critical onslaught of a breaking storm wave having a velocity of impact of "40 palms per sec." (10.32 metres).

The aforesaid truly cyclopean mass with a unit volume of 1,980 cu. metres, which constituted the foundation of the superstructure, became successively embedded in a mass of natural lava, having at the summit in relation to the mean sea level a width of 33 metres and an external stable section, after a prolonged settlement attaining a mean slope of about 6 to 1.

If the lessons of science had been better understood, above all modern science, considerable damage and expense would have been spared.

In 1873 was begun a project by the engineer, Dionisio, for widening the Zahra Harbour, which was extended until 1889.

While the Old Harbour possessed an entrance 330 metres in width, with depths of 5 to 6 metres, an area of 18 hectares with depths of 1 metre alongside quay walls of the basin to 9 metres towards the outer mouth, an extent of wharfage of 300 metres in depths varying from 5 to 6 metres, the new harbour lying between the Zahra Mole and the Fiocca Mole, furnished towards the south with two jetties, which left an opening of 220 metres, provided a surface of 68.50 hectares with depths of 10 metres and a quayage development of 900 metres in depths of 7 metres.

In 1912 was begun to the south the underwater mole, with the object of limiting the settlement in spite of the extension of inlet of breaking waves from the outside into the internal water area.

The First World War Period

The first world war brought about a stoppage of the works and it was not until the 29th June, 1919, that a convention was arrived at between the Ministry of Public Works, the Treasury and the Ministries of Sea and Rail Transport as representing the State, the Commune of Catania and the Italian Discount Bank, in which the following concessions were granted to the Commune:

(a) The construction of new works for extending the harbour of Catania, foreseen in the important programme of the 10th February, 1919, confirmed notably with the approval of the Superior Council of Public Works by the vote of the 15th March, 1919, according the right of the Commune itself to sub-let the construction to a Company so constituted and representative at the time of the Convention, of the Italian Discount Bank.

(b) The use for 70 years of the sandy area of the beach to the south of the Southern Breakwater for the extension in question between the limits laid down in Article 18 of the Law of 2nd April, 1885, No. 3095.

By the same concession, the Company was granted the right to construct and use for the period of 70 years the appliances for loading, unloading and storing goods within the bounds of the said project.

The Convention was signed on the 2nd September, 1919, and legalised by the Law of the 14th April, 1921.

*Translated from the Italian.

Port of Catania—continued

In the meantime, under date of the 6th March, 1920, the Commune of Catania sub-let to the Maritime Works Company the construction of the new works and the use of the area, reserving a participation in the use of the port equipment. The Company had been formed on the 23rd October, 1919, with a capital of 2 million lire, in which the Discount Bank participated to the extent of 1,995,000 lire.

The Company entrusted the execution of the works to the engineers, Edward and Robert Almagia, and to the Penna and Spotorno undertaking, with the reservation as to the agreed use of the port equipment.

The Port Works Undertaking of 1926

Subsequently, under the Convention of the 5th January, 1926, between the Ministries of Public Works, Finance and Communications, representing the State and the Maritime Works Company on behalf of the contractors named above, the latter renounced all direction and was relieved from all obligation arising out of the Convention of the 29th June, 1919, as regards the extension works still to be executed, and the State substituted itself for the responsibility of the completion of the remaining works to be carried out by the Catania Port Works Undertaking (Almagia and Penna and Sportono).

There remained instead, in full vigour, all the dispositions of the Convention of the 29th June, 1919, with respect to the Maritime Works Company for the construction and use of the mechanical euipment.

The Convention of the 5th January, 1926, came into force with the decree of the 4th March, 1926, No. 669.

Meanwhile the Maritime Works Company increased its capital funds to 2,800,000 lire, and then, in consequence of a loss and the partial reimbursement of bonds, it was reduced to 800,000 lire.

The failure of the Italian Discount Bank resulted ultimately in the ceding of the bonds to the liquidating body of the Bank of Sicily.

In the meantime, by the date of October 31st, 1923, all the works forming part of the convention referred to in the project were completed, following the lines as indicated in the convention, with the exception of some variation arising out of the intervening construction of the Biriaco naval shipyard on the west side of the harbour to the south of the Biscari lighthouse.

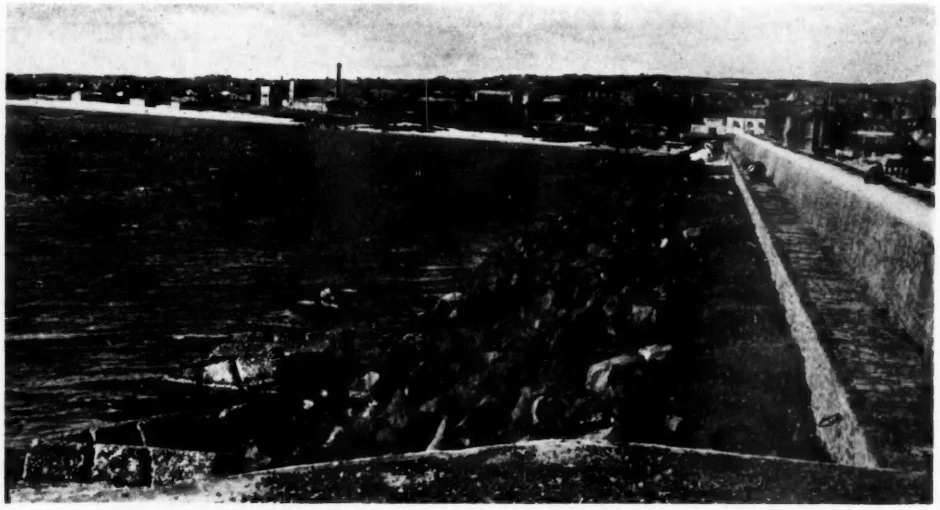
The new works comprised:

1. The extension of the second arm of the Eastern Mole to 570 metres, by the construction of a last length of 200 metres towards the south west, with a pierhead which could have protected—but, as a matter of fact, did not do so—that of the South Mole in the direction of Cape Santa Croce.
2. The formation of a triangular space for the deposit of inflammable material so as to link up the last arm of the Fiocca Mole with the projected extension.
3. The completion of the South Mole, a length of about 460 metres, and the construction of a mooring berth within the said mole, 80 metres wide, with a roadway at the root, provided with a berthing frontage in depths of about 5 metres.
4. Construction of the Western Quay for a length of 700 metres.
5. Construction of a central internal jetty with a length of 395 metres—shortened by 100 metres in the course of construction—and 120 metres wide.
6. Deepening down to 10 metres of the water space lying between the West Quay, that of the South Mole, and the western front of the New Jetty.

The order for the works was given in 1923, being allocated a period of 10 years for their execution, at an estimated cost of 84 million lire.

While the type of the substructure of the old outer breakwater, whether in the Zahra or in the Fiocca, presented a slope in equilibrium appropriate to a rubble mound, suitable, that is, to resist by absorption and natural dissipation of the dynamic energy expended during the breaking of the free outer wave within the circuit of the nuclear resistant mass, the new extension of the external mole was designed as a mixed type, having a mound below and vertical wall above, with the intention of bringing about the simple reflection of the wave without disintegration, at least theoretically, of the appreciable kinetic energy.

The cross section of the New Mole, with a thickness of 12 metres in the substructure, was executed with four layers of so-



Harbour of Catania. The beach at Plaia and the Southern Mole (1946).

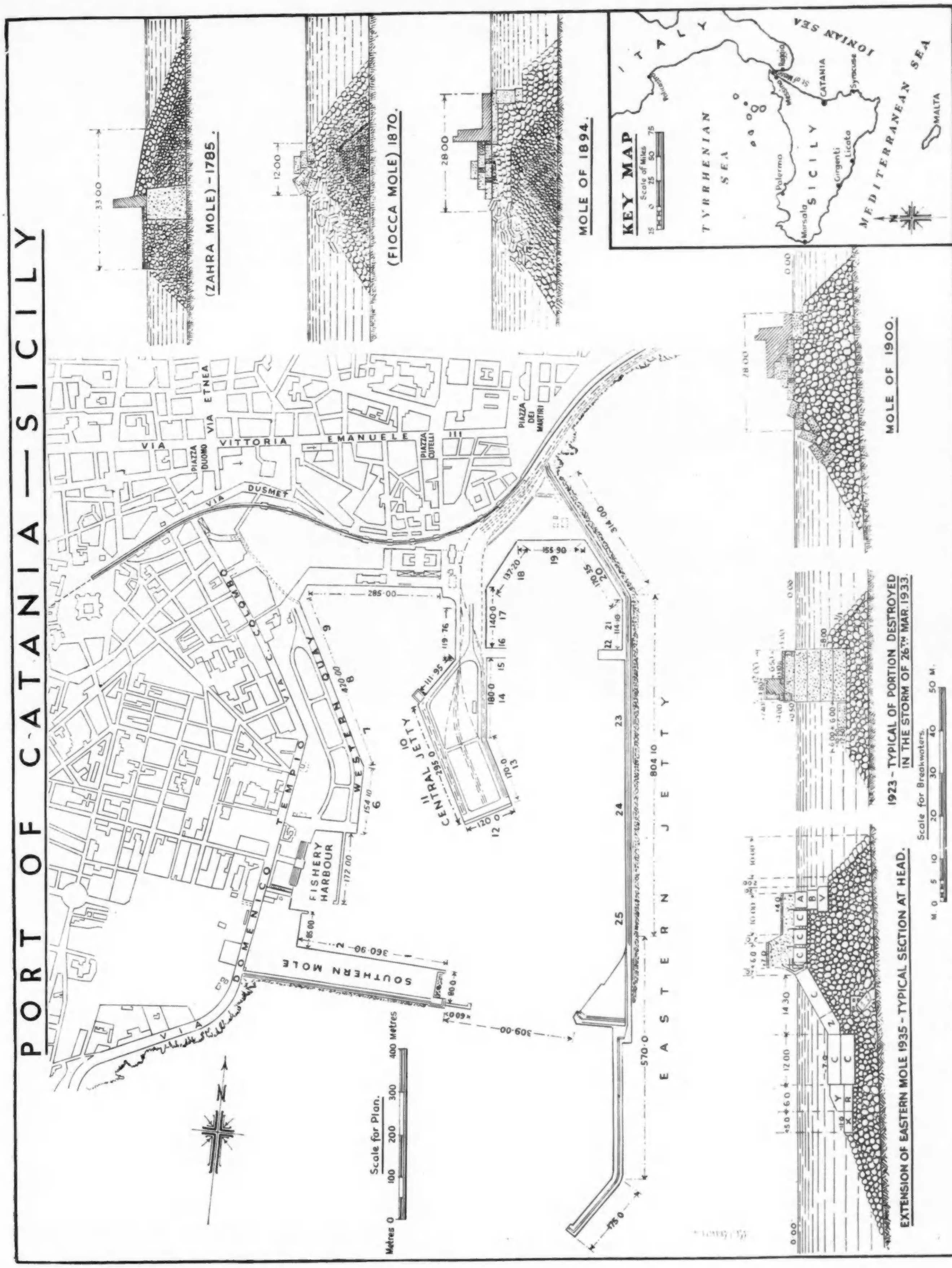
called cyclopean blocks, each 12 metres by 4 metres by 3.25 metres, founded on a rubble mass levelled to —12.50 metres and strengthened at the outer foot by a protective block 6 metres by 3 metres by 2 metres, which reached, with its upper surface, the fatal level of —10.50

We say "fatal" in so far as the renowned geologist and physiographist, Carlo Gemmellaro—who was also delegate for a number of years on the proposed Catanian Deputation of the then Supreme Direction, from which indeed has arisen the Autonomus Consortium of the Port of Catania which is called The Breakwater Undertaking—had attentively noticed during storms the breaking of waves in "50 feet and over (i.e., 15 metres) of depth."

Furthermore, while at Naples, with a fetch of 500 marine miles and a maximum height of waves, observed in storms, of 4 metres, there had been constructed rather wisely a vertical wall breakwater with a moment of resistance of 1,866 ton-metres and, at Genoa, with a fetch of 600 marine miles and maximum storm wave height of 5 metres, there had been constructed a vertical wall breakwater with a resistance moment of 1,912 ton-metres; at Catania, with a fetch of 1,044 marine miles and maximum storm wave height of 14 metres, there was proposed and executed a vertical wall breakwater with a resistance moment of 1,748 ton-metres.

The 1933 Storm.

The tempest of the 26th March, 1933, destroyed the extension of the outer breakwater of the vertical wall type, over-turning the so-called cyclopean blocks which had a unit mass of 156 cu. m. in that same harbour where, following a long technical tradition, there had been constructed blocks which did not receive the pretentious epithet of "cyclopean," but which possessed a unit

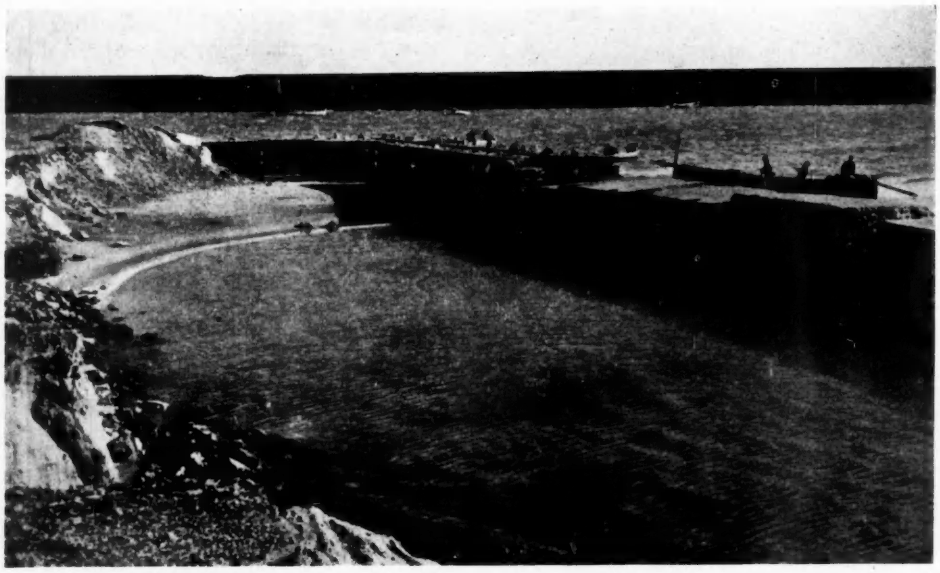

PORT OF CATANIA — SICILY
(ZAHRA MOLE) - 1785.
(FIOCCA MOLE) 1870.
MOLE OF 1894.
KEY MAP
ITALY
IONIAN SEA
TYRRHENIAN SEA
SICILY
MEDITERRANEAN SEA
CATANIA
Syracuse
Licata
Girgenti
Palermo
Marsala
MALTA
MOLE OF 1900.
1923 - TYPICAL OF PORTION DESTROYED IN THE STORM OF 26TH MAR. 1933.
EXTENSION OF EASTERN MOLE 1935 - TYPICAL SECTION AT HEAD.
Scale for Breakwaters.
VIA VITTORIA EMANUELE
VIA ETNEA
VIA DUSMET
PIAZZA DUOMO
PIAZZA CUTELLI
PIAZZA DEI MARTIRI
VIA C. COLOMBO
VIA DOMENICO TEMPIO
WESTERN QUAY
CENTRAL JETTY
FISHERY HARBOUR
SOUTHERN MOLE
EASTERN JETTY
Scale for Plan.
Metres 0 100 200 300 400 Metres

Port of Catania—continued

volume of 2,000 cu. m. It makes one think of the old tale of the modern dwarfs among the ancient columns.

In consequence of such catastrophe, due to the crowning negligence of centuries of local technical data laboriously acquired over a long period, the remnants of the destroyed work were embedded in a new mole of the rock rubble type with a steep outer slope precisely like that of the Zahra and Fiocca moles with analogous outline and dimensions, which are of the order of magnitude of the outer breakwater at Haifa (Palestine), alike to Catania in facing the greatest free stretch of the Mediterranean.

Whoever undertakes some day the comparative history of the technical elements of our harbours and beaches will be puzzled at the resultant negative balance and the evident decadence of our technical culture in the material of physiography and maritime hydraulics.



Head of the Central Jetty as damaged by bombing in the summer of 1943.

In fact, for example, during the second half of the sixteenth and the first part of the next century, the Gulf of Catania was fashioned, so to speak, by experimental observation of the first order in the field of comparative psammography and of marine physics through the initiative of distinguished students, Ignazio Paterno Castello, Prince of Biscari, Giuseppe Zahra, Charles Lyell, Carlo Gemmellaro, to mention only the chief.

Then was reconsolidated with reliable competence the laymen's "Breakwater Undertaking," in which were inaugurated and vigorously prosecuted investigations into the regime of the subtle beach of the Plaia, and was instituted the first maritime hydrographic service with an autonomous batilitological section which rendered possible, among other things, the preparation of the first fishery chart of the Mediterranean, that of the Gulf of Catania.

In times quite near to us instead, has been dispersed and obliterated the great part of the spiritual and material patrimony of that precious heredity and, among other things, there has been neglected the upkeep of the impressive Vivaio Salso of Villa Scabrosa of the Prince of Biscari, with its diaphragm of reflection at the mouth, analogous to that of the Etruscan Tagliata of Ansedonia; ignoring the secular experience of the works of the old water breakwater, there does not exist any more a modest maregraph, or any, maybe only embryo, venturimeter for the automatic registration of the dynamic pressures of sea against the protective mole nor along the coast of Etna lava, afflicted by an expanse of free sea in front which results from its great amplitude where obtain the greatest depths, exceeding 4,000 metres, and winds the most powerful throughout the whole Mediterranean.

The paradoxical modern defect, so much the more painful and symptomatic, has been thus signalised on the Port of Catania, two years before the disaster of the new Outer Mole, prophetically in the *Review of the Catania Commune* (*1931, No. 5*):

> "It would be desirable that in a new edition of 'The Downfall of Sicilian Culture,' by Giovanni Gentile, there should be added a Chapter X. on 'The Downfall of Sicilian Technical Culture,' which would prove undoubtedly interesting and to which Catania, by itself, would bring a significantly peculiar contribution."

During the period between 1929 and 1934 were completed of the works contemplated in the 1923 programme, the Quay of the South Mole, the Western Quay named after Francesco Crispi, the Central Jetty and the excavation, if not the hydraulic deposition of the dredged material to form a quay surface behind the quay walls, at an inclusive cost of 40 million lire.

In the succeeding five years, that is, from 1935 to 1939, were executed the works for the systemization and completion of the Western Quay and the Central Jetty, comprising:—

1 The construction of streets and principal squares with substantial pavements.
2 The construction and paving of secondary squares with cylindrical reloading and superficial treatment.
3 Railway sidings on the Central Jetty alone.
4 Hydro-sanitary installation.
5 Electricity installation in series for an inclusive sum of 7 million lire.

After the storm of the 26th March, 1933, which destroyed the vertical wall outer mole, with its base of four layers of artificial blocks with unit dimensions of 12 m. by 4 m. by 3.25 m., there was adopted for the construction of the new mole a resistant section with mixed external profile and with parabolic outline for the superstructure, like the natural exterior profile of the Faraglioni of Aci-Trezza, already applied in the Roman epoch in the ancient mole of Pandateria (Island of Ventotene), with rock rubble covered from the level of—12.50, with a protective mantle on the outside of artificial blocks supported and adjusted to the slope.

This new outer breakwater was formed in two distinct arms, the first of which had a length of 335.85 metres and the second a length of 186.30 metres, apart from the pierhead of 22 metres, and it cost 30,102,993.95 lire. The works were begun on 10th July, 1933, and carried through uninterruptedly to completion on 31st December, 1938.

On the 14th April, 1938, were begun the Fishery Harbour Works, comprised between the Western Francesco Crispi Quay and the South Mole; they were completed on the 25th October, 1939, at an overall cost of 1,061,498 lire. The enclosed area measured 2 hectares.

On the 31st December, 1938, were completed all the works stipulated in Article 1 of the convention of the 29th June, 1919, between the State and the Commune of Catania in the concession to the latter for the extension works of the port cited in Article 9 of the succeeding convention of 5th January, 1926, between the State Administration, the Maritime Works Company and the Company for the Works at the Port of Catania (the Almagia and Penna and Spotorno Contracts) as regards the extension and constructional works and the use of the cargo handling plant.

The 31st December, 1943, was the date of the termination of the five-year period for the completion of the port works, some of which had, as yet, not been commenced.

Hydrodynamic and Physiographical Characteristics

In the programme for the enlargement of the port drawn up at Venice on the 31st October, 1923, there was a fundamental error

Port of Catania—continued

of direction in the limits of the storm sector reaching the pierhead of the projected outer mole, as also in that of the submerged mole.

In fact, while the tangent from the mouth of the port to Cape Spartivento was drawn in the project in the direction N.E. (azimuth, 45°), the tangent actually had an azimuth of 60° 30′ 11″ lying between N.E. ¾ E, and E.N.E.

Also, in the second quadrant, the tangent to Cape Santa Croce, while in the project it was traced in direction S.E. (azimuth 135°) had actually an azimuth of 152° 5′ 40″ .8 lying between the directions S.E. ¾ S. and S.S.E.

Now, with the object not only of protecting the internal water area from the prejudicial effect of the shock due to the entrance and subsequent reflection of the greatest storm waves, but in the hope of sensibly reducing also the deposit arising from the Simeto, it would be necessary to extend by a hundred metres at least the second arm of the new outer mole, at one time prolonged by 60 metres, it having already been done in correspondence with the port entrance as projected on 31st October, 1923, for the South Mole.

In reference, then, to the intensity vector of the Outer Mole in the first quadrant, the limit of the stormy sector grazing Cape Spartivento reaches as far as the island of Corfu, with fetch, measured orthodromically, of 250 marine miles.

In the second quadrant, the limit of principal storm sector, tangential to Cape Santa Croce, reaches as far as the Gulf of Sidra (Great Sirta), with a fetch of 480 marine miles.

The sector of maximum storm influence, tangential to Cape Crio in the island of Crete, and protracted as far as the coast line of Southern Palestine (Haifa) to the West of Jerusalem, gives a fetch of 1,044 marine miles, in which lies the greatest depth of the whole Mediterranean (4,404 metres).

The slantwise cut of the littoral platform in front of the Eastern Mole at Catania, distant only 4 kilometres beyond the latter, in the direction E.N.E. (fetch, 252 marine miles; maximum depth therein about 2,000 metres; maximum height of storm wave, measured during the E.N.E. storm of the 26th March, 1933, 7.40 metres; length of wave, 228 metres; period, 12 seconds), commencing to break in the adjoining slope of the foreshore in a depth of 100 metres, while that in the direction of greatest storm intensity in the second quadrant (fetch, 1,044 marine miles; maximum depth herein exceeding 4,400 metres; maximum height of storm wave, measured 15th December, 1881, on the occasion of a violent storm from the E.S.E., 14 metres), the said ugnature (slantwise cut) dips instead to a depth greater than 200 metres and at a distance of about 6 kilometres beyond the Eastern Mole.

No harbour in the Mediterranean, therefore, presents hydrodynamic and physiographic characteristics comparable with those of Catania, which have been frequently the subject of animated discussion at International Congresses of Navigation.

Of vital importance, then, for the actual maintenance of the Port of Catania is the regimen of the flat beach of the Plaia, where debouches at a distance of 5 miles from Catania the Simeto, the greatest river of Sicily, which, in the year 1938 alone, has transported to the sea fully 3,810,000 tons of material in suspension, in part conveyed by the sea by under water currents towards the outer harbour of Catania.

Carlo Gemmellaro, in 1836, as a basis for the systematic measurement of the protrusion of the shore then achieved, foresaw that the onset of the Plaia would reach the Point of Sciara Biscari in 663 years, that is, in the year 2500.

From 1836 to 1928, the root of the northern inset of the Plaia had advanced instead 270 metres, that is, more than half of the 516 metres lying between the beach of 1836 and the Point of Sciara Biscari had been invaded in 92 years alone.

To-day has been not only reached but surpassed the Point of Sciara Biscari by the beach in extending itself and the fate of the existing harbour of Catania seems threatened at no distant date wherever there has not been hastily constructed another under water mole with reflection diaphragm to the south of the South Mole or wherever other safeguarding measures have not been taken with, at least, temporary efficiency to protect the mouth of the outer harbour from the fearful invasion of the sea of sand which, as has already happened at Pisa, threatens to make Catania also a "sea-widow," as has been acutely pointed out by a bold technician, Pilo Sighieri, who has collaborated in the modern "Breakwater Works" and who, with uncommon energy and competence, has occupied himself thoroughly with this difficult and grave problem.

The greatest inroad achieved at the most violent epoch of the storm by infringement on the bank along the emerged zone of the the Plaia, the limit of which is clearly and distinctly defined by the bordering of seaweed deposited there recently after having been torn from the sea bed by storm waves, represents the fundamental element of the degree of intensity of storm at Catania.

Carlo Gemmellaro, to whom we owe the masterly first systematic scientific study of the regimen of the Mediterranean beaches, has set out (referring to his observations made on the Plaia from 1800 to 1836), "that the sea in violent storms drives the waves expanding on this beach as much as 50 canne (103 metres) beyond where they ordinarily break."

Base of crest with cyclopean blocks.

During the seaquake of 28th December, 1908, such a distance, commencing from the breaking line, had reached 700 metres in correspondence with a wave height of 17 metres to which, however, the old Eastern Mole of the rubble type had offered effective resistance.

During the storm of the 26th March, 1933, which overturned the new vertical wall mole, such a distance reached 225 metres.

The historian, Pietro Carrera, has preserved the record of a memorable storm which broke out on the 4th February, 1590, when the waves broke on the shore so violently as to obstruct the passage of the Fercolo of Saint Agatha beyond the boundary of the old wall of the town, so much as to be attributed to a real miracle, the traditional transport of the saint, in correspondence with the Porta della Decima which the waves hammered in such a impetuous storm and which, at the beginning of the 17th century, had been referred to by the engineer, Raffaello Lucadello, as distant from the beach by 200 canne (413 metres).

Further notes on the periodical analysis of the more memorable storms at Catania are contained in the Annali dei Lavori Pubblici (1937, Nos. 3-4).

Most interesting also are the maregraph records made in the Port of Catania, which are no longer kept, the apparatus having been transferred elsewhere. The instrument was a maregraph of the Mati type, modified by Ricci, put into action on the 14th July, 1889; the maregraphic station was connected with the network of precise geometrical levelling.

At Catania, the establishment of the port (that is the time interval on the day of the syzygies, and approximately also on other days, which elapses between the passage of the moon over the meridian and the following high water) is about 3 hours 30 minutes.

The soundings on the nautical charts of the Hydrographic Marine Institute are not based, as regards Catania, on mean sea

Port of Catania—continued

level, but on the datum —0.12, being the outcome of 12 c.m. difference between mean sea level and the mean level of low water at the syzygies (reduction plane of the soundings).

The height above mean level of the highest high water in the syzgies is about 22 c.m. The height above the mean level of the lowest high water in quadrature is about 15 c.m.

The incursion of the tidal level in conjunction with external winds and notable barometric pressures and depressions exceeds 60 c.m. along the quay wall of the mooring berth.

Moreover, the mean level of the sea at Catania, according to observations made in the period 1901-1910, oscillated annually with a maximum range of 11.2 c.m., from a maximum height of +6.6 for the month of November to a minimum of —4.6 for the month of May.

Examination of the maregrams at Catania has led to the selection of secondary oscillations (seiches) which, in general, present an amplitude not exceeding 10 c.m. in a period of 17 mins.

From experiments carried out in the Gulf of Catania, it has been ascertained that the course of the littoral current on the surface follows a depression in the path of the slantwise cut of the littoral platform with direction from north to south and with a velocity which has reached some 20 centimetres per second.

" The flow of the Simeto—as is pointed out, however, in regard to Catania in the Pilotage of Sicily—when it is turned towards the north by winds of the Scirocco, prevailing during the winter, arrives with its turbid waters close to the entrance of the harbour, when it encounters a current produced by the tendency of the harbour waters to flow across the entrance.

" The prominent irregularities of bottom existing in the area of water to the south of the harbour lead to the supposition that there has not been, due to the effect of this current, the formation of a true and proper bar, but that the material transported by the flow of the Simeto is deposited in an irregular manner which is without risk of danger to navigation."

Bars, humps and littoral benches show themselves, however, in the outer harbour beyond the line of impact on the beach, which is in a phase of appreciable encroachment, so much as to have buried the lavitic shore of 1669 and the same Point of Sciara Biscari, with a clear tendency to settle ever more at the root of the external rock-work of the under water mole.

The depths of the harbour entrance up till now are maintained thanks to the reflection produced in the outer harbour by the vertical wall quay on the inside of the extension of the old outer mole and will so maintain themselves until the actual morpho-lithologic equilibrium can be continued into the stage of a new beach in front.

By the same method was shaped the technical Etruscan process, eruditely described by Raffaele Del Rosso, of natural defence by the sea deposits of the very old " Tagliata dell 'Ansedonia," at the mouth of which had been left " a diaphragm of vivid rock to reflect the waves, that hold the S.W. and S. wind." Thanks to this expedient " the Etruscan outlet has for three thousand years been free from any obstruction of sea-wrack and sea-sand."

This very ingenious process dates back to pythagorean times and the tradition which assigns it to the canals of Empedacles at Selinunte, Agrigento, Kolymbetra, likewise " Fosse Filistine," which the Sicilians of the Greek colonies excavated with ancient apparatus at the mouth of the Po, not far from Spina and Adria.

The above-mentioned process was brilliantly applied in the 17th century at the mouth of the canal of communication with the open sea of " Vivaio Salso di Villa Scabrosa " by Ignazio Paterno Castello (1719-1786), Prince of Biscari, who, with this aim in view, made use of the advice of an eminent expert in maritime hydraulics—the Maltese engineer, Giuseppe Zahra—and of an ingenious Etruscanologist, the Tuscan abbe Domenica Sestini, reorganiser of his Antiquities Museum, likewise of his Natural History Museum, and author of the classic treatise of the " Illustrazione di un vaso antico di vetro ritrovato in un sepolcro presso l'antica Populonia " which was useful to Giambattista de Rossi, to Jean Victor Coste, and to Raffaele Del Rosso, in the monumental attempt to reconstruct the outline, fallen into oblivion of the modern epoch, of the most ancient artisan tradition of the molluscculture of the Etruria and of the Magna Cræcia.

Of the wonderful Biscari's "Vivaio Salso" there survive to-day, in spite of the maintenance's pyramidal negligence, following the loss of the big archæologist and naturalist from Catania, the superstructures of defence uays—" saxa loquuntur "—abandoned and half-covered by the sea-sands of the shore of recent formation.

(To be continued)

London Dockers' Pay-Day

New Scheme Brings More Problems

Complaints made by London dockers at the decision to pay them on Fridays instead of Thursdays draw attention to the vast and complex organisation under which a wage bill of approximately £160,000 is paid each week to over 21,000 men distributed along more than 40 miles of Thames-side.

The Port of London Authority, who are the accounting agents for the National Dock Labour Board for the Port of London, receive daily information about work done by individual dockers from some 350 separate employers. Wide ranges of pay are involved, according to the type and amount of work done, and an added factor is that a man may have worked for several different employers in one week. As a result, a normal week's pay-roll is an aggregation of some 200,000 separate items of pay.

The official week finishes on Saturday. Attendance cards are deposited by the dockers, or their employers, by 11 a.m. on Monday, and not until then can the P.L.A. begin making up the pay-roll. After computing each man's pay for the week, tax and national health insurance deductions must be made. When the pay-roll is complete the actual money is sorted and made into pay packets at the various dock pay centres.

The complex accounting work necessary to compute each man's pay is done with the aid of machinery valued at some £60,000. To ensure continuity in the event of failure in the electric supply, a Diesel generator has been installed. The accounting staff number some 70—about a quarter of the number which it would be necessary to employ without the aid of machines.

Staff Problem

To complete the pay-roll in time for the Thursday pay-day, these machines have to be used for very long hours. The operators so employed are on a shift system, but the extreme difficulty of obtaining sufficient skilled staff means very long hours, and every member of the staff works regular overtime. Most of them have been doing so for more than five years. The usual hours have been from 9 a.m. to midnight on Mondays, to 11 p.m. on Tuesdays, and 6 p.m. on other days.

The new guaranteed week for dock workers has added a further burden to the accounting clerk. Requiring further calculations and, where necessary, adjustments to ensure that each worker receives at least the new minimum wage, this extra work means several more hours. Shortage of staff, restricted accommodation and the impossibility of obtaining more machines and making other arrangements until the conditions of the prospective guarantee were known, and the future of the pay organisation under the new board were settled—all these have made a Thursday pay-day impossible. Even a third late night working of the machines would not give sufficient time for the dock pay centres to make up the pay packets.

The decision to pay on Friday instead of Thursday has been the only solution to this particular problem, one of many surrounding what, in size and complexity, is probably the biggest pay organisation in the United Kingdom.

PORT OPERATION

Part Nine of a series of articles by A. H. J. BOWN, M.Inst.T., A.C.I.S.
and Lt.-Col. C. A. DOVE, M.B.E., M.Inst.T.

(Continued from page 99)

Part 4 (B): Cargo Handling

Quay Cranes

Quay cranes are provided for the purpose of loading and discharging ships in most modern ports in Europe and in areas under British influence.

From an operating student's point of view, the salient components of a quay crane are (a) the crane box or cabin in which the machinery and the crane driver are housed and its contents, (b) the crane jib, which corresponds to the ship's derrick, (c) the wheel (sheave) at the free end of the jib (jib head), (d) the crane chain or wire which is used for hoisting or lowering cargo. This wire is led from the crane box, where it is usually affixed either to a drum or to a piston or ram via a series of pulleys, over the sheave at the jib head, down to its free end to which a hook for cargo lifting is attached. To prevent the crane wire kinking when a load is not suspended and thus curling back over the sheave and jamming it, the wire is weighted just above the hook with a metal ball. This weight has the effect of keeping the wire taut when it is free. In addition, it eliminates excessive swinging of the set when hoisting or lowering, (e) the pedestal and/or the gantry on which the crane is mounted, (f) the motor and wheels which invest the crane with mobility.

Motions

Modern quay cranes are capable of four different motions, (1) hoisting or lowering, (2) slewing, (3) luffing, including level luffing, and (4) travelling.

Hoisting

Hoisting and its reverse operation of lowering refers to the lifting and lowering of the set by hauling in or paying out the crane chain or wire from which it is suspended. This motion is responsible for the vertical movements of cargo when it is being transferred by quay crane from ship's hold to pitch or vice versa.

Slewing

Slewing is the name given to the motion of the crane jib as it pivots on its axis and is responsible for the horizontal movements of the cargo.

Luffing

Luffing (or derricking) is the word used to describe the up and down movement of the jib itself. All cranes were at one time constructed with fixed jibs, i.e., jibs which were only capable of being slewed. Luffing is a comparatively modern development which has the effect of allowing the outreach of the crane to be increased or decreased (outreach is the radius of the arc or circle described by the crane jib as it rotates about its axis, i.e., the shortest distance between the axis of the crane and the crane chain when in the lowered position), thereby increasing the number of inboard and outboard points which the crane can plumb. In the case of cranes with fixed jibs, these points are restricted to the pathway described by the single radius of the crane. Cranes are marked with their safe working loads in prominent places inside and also outside the crane box. In the case of luffing cranes the S.W.L. varies inversely with outreach, i.e., the greater the outreach the smaller the safe working load, a common S.W.L. of a modern crane would read "3 tons at 65-ft. radius, 2 tons at 80-ft. radius." In practice it is found that the luffing motion (a) reduces the amount of "placing," i.e., positioning of the crane, which characterises the use of fixed jibs, during the course of loading or discharging, (b) increases the number of outboard pitches, thus minimising congestion, (c) increases the number of points which the crane can plumb in the hold, thereby (1) increases the possibility of straight lifts and thus minimises the danger of sets swinging into the sides of the hold or other cargo stowed in the hold, (2) reduces the practice of "dragging" cargo in the hold, (3) aids labour by making it possible to take the hook to the point in the hold most convenient for making up or receiving the sets, instead of moving the cargo from the stowage to the hook or vice versa.

Modern cranes are level luffing, which means that the load can be kept at the same height whilst being slewed whatever the angle of the jib.

Travelling

Travelling is the word used to describe the mobile characteristic of a crane. Practically all quay cranes are mounted on wheels which run on railway or tram tracks set in the quay and to that extent may be regarded as travellers. The older types of quay cranes, however, had to be moved by hand, by means of pinch bars and sometimes by cranking handles. The moving of such cranes even over short distances entails the loss of much time. Within the authors' experience hand-propelled quay cranes have taken three-quarters-of-an-hour to move from one hatch to its neighbour. It is important, therefore, that not only should travelling machinery be installed, but it should be of sufficient horse-power to make the transference and the accurate placing of the crane a rapid and facile operation. An ample speed would be about 2 or 3 miles an hour. Where cranes are provided with fittings for clamping them to the rails, they should be fixed before any lift is made and also on completion of work, particularly in windy weather, when the further precaution of slewing the jibs in the direction of the wind should be taken.

Portal Cranes

To derive the maximum benefit from the crane's outreach and to provide the crane driver with the best possible view of the ship's hold, the crane box should be situated above the coaming of the largest ship likely to be worked by the crane when she is light, i.e., when she is highest out of the water, and in the case of tidal quays when the tide is at its highest point. For this reason, and to permit the crane jib to plumb more than one floor of a double or multiple storied transit shed, the crane box and the jib should be mounted on a pedestal. In order that the crane mounting should form the least possible obstruction on the quay, the pedestal should take the form of a portal, wide enough and lofty enough to allow locomotives and loaded rolling stock to run between its legs. Cranes mounted on such pedestals are known as portal cranes.

Semi-Portal Cranes

Where the quay apron is narrow and is provided with transit sheds, semi-portal cranes are sometimes constructed to limit the space taken up by the crane legs. Such cranes are mounted on two wheels running on a single line on the quay and on wheels running along a track laid on the shed roof, or along a ledge lower than the roof. Semi-portal cranes frequently possess the additional advantage of travelling along the gantry at right angles to the quay edge as well as parallel to it.

Power

Hydraulic or electric power is usually used for driving quay cranes mounted on pedestals or portals. Steam is now rarely used for quay cranes at ships' berths owing to the inconvenience of hauling water and fuel up to the crane, and the increase in the congestion on the quay caused by the transport required for the fuel. Where coal is used the danger of fire arises from the presence of hot ashes. This last disadvantage can be overcome by using oil-fired boilers. Steam cranes are, however, simple to operate, reliable, and possess the additional advantage of being operated as units, thus being independent of central power failures.

Port Operation—continued

Hydraulic and electric cranes are operated from central sources of power which can be used for other purposes, e.g., hoists, lifts, capstans, pumping plant, lock gates, and in the case of electricity, lighting and heating. The pipes for the hydraulic cranes or the cables for the electrics are laid under the quays which are fitted with hydraulic connections, or in the case of electricity, with plug boxes. These are situated at intervals along the quay which will allow the quay cranes to be placed, when necessary, to plumb any part of the berth within radius of their jibs. As an alternative to the plug box method a continuous contact line is sunk in a trough in the quay deck.

Lifting Capacity

Capacities of quay cranes depend upon the cargo being handled, but a useful capacity for general cargo working is between 2½ and 3 tons. Experience shows that the average set is very much less than this, in fact an average taken from twelve general cargo ships recently over a period of a month, revealed that of the 100 sets checked only twelve averaged over one ton and none of these exceeded 25 cwts. It is estimated that less than 10% of the lifts made at general cargo berths weigh more than 3 tons. Nevertheless, the presence of only one such lift makes it necessary to provide lifting power to load or discharge it. Experience has shown also that the provision of one quay crane, capable of lifting 5 or 6 tons in addition to those of smaller capacity, is justified on most general cargo berths.

Outreach

It is difficult to generalise about the outreach of quay cranes. which depends on the beam of the vessels using the berth and the landward area to be served. For coastal or similar small vessels 50-ft. would probably prove to be an economic outreach, for large vessels discharging or loading at wide berths served by several lines of traffic and a large stacking area or transit shed, anything up to 100-ft. might prove an economic proposition. Normal outreaches on such berths range between 65 and 85 to 90-ft.

Characteristics of Quay Cranes

The value of modern quay cranes may be summed up as follows: (a) They are independent of inboard power failures, (b) they may be used for loading or discharging land and water conveyances when there is no ship at the berth, (c) their great outreach, luffing and travelling motions permit them to plumb many points with great accuracy both inboard and outboard, thus facilitating work in the hold and assisting to reduce congestion ashore, (d) the choice of pathways afforded to their sets by the slewing and luffing movements, (e) each purchase requires only one driver.

Ships' Gear and Quay Cranes

In assessing the relationship of ships' gear and quay cranes for cargo handling purposes at ports, the student should learn to regard them not as competitive but as complimentary. In deciding whether to use ships' gear or quay cranes or both, each case must be considered on its merits in terms of efficiency of cargo handling, ships turn-round and overall cost. In considering cost it must be borne in mind that both ships' gear and quay cranes represent a heavy capital charge and although the direct cost is borne, in one case by the shipowner and in the other usually by the port undertaking, the aggregate cost of both is ultimately included in the total cost of transport from producer to consumer. Sound judgment must be shown therefore in deciding on the number of quay cranes to be provided so as not to embarrass operators with lifting power which cannot be satisfactorily employed.

Travelling Steam Cranes

Cranes mounted on pedestals and portals are not necessary on lighterage berths or in yards or other parts of the dock area where the striking and loading of land conveyances and the piling and unpiling of cargo takes place. For such purposes steam cranes mounted on standard gauge railway bogies are often used. The advantage of these cranes is that they can travel under their own power to any part of the dock estate which is rail served for the purposes of working or replenishing fuel and water. One drawback to their use arises from the risk of fire from hot ashes and sparks, but this danger can be guarded against by fitting pans to catch hot ashes which fall from the cranes, and by fixing wire cages or cowls to their chimneys to trap the escaping sparks. The capacity of such cranes varies widely, from 30-cwts. up to the 50 or more tons of the breakdown crane. Where a dock railway is provided with a breakdown crane its potentialities as a heavy lift crane when it is not required for its normal function should not be overlooked.

Mobile Cranes

A mobile dock crane is a crane which can be driven under its own power to any point on the dock estate to which there is reasonable access. Modern mobile cranes are capable of slewing, luffing, level-luffing, hoisting, lowering and travelling. Some are designed so that they can turn in their own length and thus function as slewing cranes without being fitted with slewing mechanism. Many of the older types do not slew or luff. The lack of these movements, particularly the former, involves a considerable amount of manœuvring particularly at busy and congested points, for their absence makes it necessary to back the crane out with each load before it can be deposited instead of allowing it to remain stationary and slew with its load.

Care should be taken to avoid the temptation to carry loads unnecessarily. Although mobile cranes are undoubtedly successfully designed to travel with their loads, experience has shown that by so doing (1) the wear and tear to the crane itself is greatly increased and (2) the inevitable swinging of the set creates the possibility of damage both to the load and the crane. Where it is necessary, therefore, to move a set for any considerable distance after it has been lifted, consideration should be given, where possible and practicable, to using some other means of conveyance, e.g., a 4-wheeled truck once the initial lift has been made by the crane. In these circumstances, of course, it is necessary to make arrangements to unload the truck at destination, e.g., by hand or by another mobile crane or by a piler.

It is to be noted also, that as with other types of cranes, mobile cranes rarely make capacity or near capacity lifts. To compensate for this loss of lifting power, which is accentuated when cranes are running about with their loads, work should be organised so that as many lifts as possible are made during the working period. It is, of course, often an economic and practical proposition to keep trucks waiting on a mobile crane until they have been loaded to capacity or near capacity.

For comparatively light work on reasonably good surfaces mobile cranes are mounted on tractors in lorry style, with pneumatic tyres for preference, but for heavy and/or rough work, particularly on bad surfaces caterpillar track mountings are used. Some cranes are designed so that the driver's seat moves with the jib, this permits of the crane being designed (a) to slew through a full circle and (b) to provide the driver with a frontal view of the load through a full circle.

Mobile dock cranes range from light models designed to lift up to 30 cwts. to those capable of handling 50 tons. The usual range is from about 2 to 10 tons. For average dock working a jib of 14-ft. which can be increased by about 6-ft. by means of an auxiliary attachment is satisfactory. Crane jibs are marked with the S.W.L.'s and the corresponding outreaches.

Probably the most important factors in getting the best use and the longest life out of a mobile crane are the skill of and the care shown by the driver. For this reason not only should mobile crane drivers be well trained, but wherever possible the same crane should be driven by the same driver.

Scotch Derrick

A scotch derrick is a stationary steam, diesel electric or oil-fired crane. Its main component is the metal jib or boom which pivots on a king post in much the same way as a ship's derrick pivots on a samson post. Sometimes to give it greater height the whole derrick is mounted on a framework. Owing to the position of the supports for the king post the jib cannot slew through a complete circle. The large area required on which to set up a scotch derrick is a drawback to their use, but provided they are carefully

Port Operation—continued

sited they can be particularly effective for handling regular flows of comparatively heavy lifts to and from lighters and land conveyances. A good site would be provided at the junction of two rail and road served lighter berths, where they are aligned so that the proportion of land to water is 3 to 1, for the derrick can then be made to plumb two lines of lighters at both berths and the landward areas supporting them, without interfering with the main flow of traffic through the dock or wharf. The handling of heavy lifts either direct to water or land conveyance or to stack, usually entails a considerable amount of scotching, shoring up and sticking (placing of pieces of timber between the packages) which means that the derricks stand idle for lengthy periods between lifts, unless they can work to two or more pitches at the same time.

In this connection the student should remember that it is characteristic of practically all expensive equipment used in docks that although it tends to be a heavy charge against capital, it rarely wears out before it becomes obsolescent, for example, many of the quay cranes in use in this country are over 40 years old. Consequently they are out of date and expensive to run by modern standards. For this reason alone, thought must be given to finding ways and means of putting expensive equipment to the maximum use possible compatible with economic and efficient dock operating.

Sheer Legs

A sheer legs is a fixed structure which functions as a crane. Its characteristic features are three legs mounted in pyramid fashion on a triangular base, with the apex tilted over the area from or on to which the lifts are to be hoisted or lowered. A lifting chain or wire is run from the hoisting machinery housed at the base of the sheer legs, over the apex, which fulfils the role of a crane jib head, down to a cargo hook or shackle.

Sheer legs are mainly used for hoisting heavy lifts to considerable heights. They can be designed to hoist almost any heavy lift and are very simple to operate.

Their main disadvantages from a port operating point of view are (1) the lifts have to be taken to the sheer legs, and (2) owing to their size they immobilise large areas of quay space, a particularly serious drawback to their erection, when, as is often the case, they are not required for long periods between lifts.

Floating Cranes

Floating cranes have now come to be regarded as a standard facility in most modern ports. Some are self-propelled, others are dumb, i.e., they are unable to move under their own power and require to be hauled into position by some other agency such as a tug. Sometimes they take the form of a floating sheer legs instead of a crane. Generally speaking, they are made with sufficient outreach to plumb the hold of any ship likely to use the port and their capacities range from 5 tons to 200 tons, depending upon the work they are likely to be called upon to perform.

The advantages of heavy lifting floating cranes are (1) they can be moved to the site of the lift, (2) they can travel with the lift suspended from the crane hook or shackle if necessary, (3) they save ship turn-round time by eliminating (a) the time lost rigging the heavy derrick at the hatch at which the lift is to be made— anything from 6 to 24 hours, (b) the time lost dismantling and re-rigging the light derricks both at the hatch where the lift is to be made, and at adjacent hatches on those ships where additional winches are not provided, (c) the time lost at other hatches whilst winches are in use assisting with the lift—where this is necessary, (4) they make it possible to avoid the practice of loading heavy lifts all together at one time, as frequently takes place at expense of trim and good stowage, to avoid losing the time taken to rig the heavy derrick more than once, (5) they enable a regular crew to specialise in heavy lifts, (6) they can be used for other work as well as loading and discharging ships.

Two-Wheeled Hand Trucks

Two-wheeled hand trucks are much used in many countries for transferring cargo from place to place. They are convenient and efficient for handling light homogeneous cargo over short distances, although models have been adapted for handling such commodities as cotton bales, bagged cargo and drums. In some circumstances they are useful for handling cargo in the holds of ships. As two-wheeled trucks are hand-operated good surfaces are necessary to get the best results. The older forms of two-wheeled hand trucks were designed with iron-shod wheels. Labour is saved much fatigue and wear and tear is reduced by using wheels fitted with pneumatic tyres and ball bearings.

Four-Wheeled Trucks

Four-wheeled trucks are constructed so that they can be hand-propelled or power-propelled. Their advantages over the two-wheeled truck are (1) they can be more easily placed directly under crane or ship's gear, (2) they are bigger and of greater capacity, (3) whether they are hand-propelled or power-operated they are less fatiguing to labour. When they are power-propelled either petrol or electricity is generally used.

Photo by Courtesy of George Halliday & Ross Carrier Co.

A Timber Carrier

Some of them are made so that the platform of the truck can be lowered and fitted under a tray raised a few inches above the ground. The advantage of this type is that it enables sets to be made up on the trays while the truck is running about with other loads. As a result the idle time spent by the truck waiting for loads is reduced to a minimum.

Tractors and Trailers

Considerable use is made of three or four-wheeled petrol or electrically-driven tractors for hauling four-wheeled trailers. These tractors are made narrow and designed with a short wheel base to enable them to work in restricted areas. Some are constructed to turn in their own length. Many are designed so that they can push or pull a load. One important advantage of using tractors and trailers is that the tractors may be used elsewhere while the trailers are being loaded or discharged. They may be used with considerable success when loads have to be carried long distances. Care must be exercised in selecting trucks with couplings which whilst being easy to couple and uncouple, are so designed that they are not jerked out of position by rough surfaces or sharp turns.

Timber Carriers

Timber carriers are powered vehicles which are constructed to straddle their load or set, pick it up and transport it. As well as timber in pieces they may be used to handle long cases, lumber, pipes, girders, etc. When timber is to be carried it is piled on two or more cross-pieces. The stack is then straddled by the carrier which raises it from the ground by lifting the cross-pieces on which the stack is piled or placed. These vehicles can move with equal

Port Operation—*continued*

facility in both directions and turn in a small radius. An important feature in those fitted with pneumatic tyres is that they are self-jacking. In the event of a puncture this enables the carrier to be jacked up and the wheel changed without unloading.

Mechanical Shunters

In some ports mechanical shunters are used instead of capstans or in preference to hand-shunting, for placing railway wagons Mechanical shunters are tractors made so that they can push and pull railway wagons. They can also be employed for hauling trailers. Sometimes they are used for pulling quay cranes into position. This practice is not to be encouraged for it is liable to cause damage to the flanges of the crane wheels.

Fork Lift Truck

The fork lift truck is an important and comparatively modern innovation in the docking world. It is a self-propelled truck fitted in front with a platform which takes the shape of two prongs of a fork. This fork-shaped platform can be raised under its own power, from floor level to heights ranging according to the size of the truck from 5 to 15-ft. or more. It can be lowered in the same manner to floor or any other intermediary level. A further characteristic of the truck is that it can travel with its load at any required height up to its maximum. The capacity loads which can be lifted and carried on the fork vary, according to the type of truck, from 2 tons upwards.

The truck is loaded by lowering the fork to ground level and driving the truck gently forward so that the fork passes under the load. To avoid damaging the load (set) or the cargo-handling gear on which it is made up, the prongs of the fork are tapered to a wedge shape. When the fork is under the load it is raised to the height required for travelling, and tilted backwards slightly by mechanical means to prevent the set falling off.

The fork lift truck can be applied to a wide range of cargoes to produce a considerable economy in double handling. For homogeneous cargoes which would otherwise be handled on an ordinary cargo tray, e.g., cased provisions, it is used in conjunction with a type of cargo tray called a " pallet," which will later be described in more detail.

Roller Runway (Conveyor Rollers)

For handling a good run of homogeneous packages in the hold or on the shore over distances, roller runway is often used. It consists of rollers about 12 to 14-in. wide set between metal bars made in various lengths, the limiting factor usually being weight, for it has to be put in position by hand. It is designed so that the lengths can be joined together to make a continuous pathway.

It can be worked under gravity or by power. When gravity is used the gradient should be varied between 1 in 50 and 1 in 20, according to the weight of the cargo to be handled. To enable bends to be negotiated curved lengths are manufactured.

The runway should be set up on trestles provided for this purpose. The prevalent practice of using packages taken from the cargo should be discouraged.

Roller runway is not suitable for bagged cargo unless used in conjunction with boards which prevent the bags catching in the runway.

The big disadvantage of roller runway for shore work is that it restricts the movement of other traffic in the transit area. Where this is not likely to occur, however, it is an important factor in speeding up handling, particularly over poor surfaces.

Dock Locomotives

The locomotives used for dock working are usually of shorter wheel base than those to be found in main line depots and yards. This difference in design is necessitated by the sharp curves encountered in dock systems, particularly those designed on the jetty principle.

Such locomotives are usually operated by steam but diesels are beginning to be used. One important advantage of the diesel from the dock operator's point of view, is that it is a smaller fire risk, a matter of considerable importance where such inflammable cargoes as timber or petrol are handled.

It is also claimed for the diesel locomotive that it can be operated by a crew of one, requires no elaborate shed accommodation, requires less space for the storage of fuel and water and is easily maintained.

(To be continued).

National Harbours Board of Canada

Excerpts from Annual Report for 1946

Shipping and Cargo Tonnages

Vessel arrivals in 1946 numbered 39,823, the aggregate net registered tonnage being 26,878,748. The comparable figures for 1945 were 38,467 vessels, aggregating 29,046,089 net registered tons.

The aggregate cargo tonnage in 1946 at all harbours administered by the Board was 27,172,020, as compared with 30,082,747 in 1945. The decrease was 2,910,927 tons, or 10% due in large part to a reduction in the volume of grain shipments.

Revenues and Expenditures

Operating revenues of all units administered by the Board amounted to $11,521,551, as compared with $13,395,824 in 1945. The decrease was $1,874,273, or 14 per cent. Of that amount, over one million dollars represented reduction in earnings of grain elevators but practically all other divisions of harbour facilities, including wharves and piers, sheds, terminal railways, cold storage warehouses and floating and shore equipment showed decreases, thus reflecting adjustments in harbour activity in the first complete post-war year of operations. The two traffic bridges operated by the Board were an exception to this trend with higher revenues.

Expenses of administration, operation and maintenance in 1946 were $6,466,606, as against $6,851,249 in 1945, a decrease of $384,643, or 6 per cent. Cost of administration increased by $154,000, mainly due to a greater amount being required to pay the Board's contribution to the pension fund for employees under the extended coverage authorised in 1945. The Board paid out $353,000 for this purpose in 1946, as against $214,000 in 1945. Operating expenses decreased by $564,000, consequent upon the reduction in the volume of business, particularly of the grain elevators, but this figure was small proportionately to the decline in revenues. Expenditures on maintenance of properties were $25,000 more than in 1945, but it was not found possible, under conditions prevailing as to the supply of materials and labour, to complete the year's programme of work. Consequently, certain jobs had to be carried over into 1946.

As a result of the severe drop in revenues, tempered by relatively small reduction in expenses, operating income fell to $5,054,945 in 1946, as compared with $6,544,575 in 1945.

After taking into account debits and credits to income, and charging interest and reserve for replacements, the operations for 1946 resulted in a net income deficit of $4,558, 678, as compared with $3,088,650 in 1945. The increase in the deficit in 1946 was, therefore, $1,470,028.

Higher costs of operation due to increased wages and prices of materials are seriously affecting the net return from the Board's operations. Services are rendered for the most part under tariffs that have been in effect without change since before the war; in some cases they date from quite a few years prior to the war and are out of line with present-day costs. The operations of such facilities as grain elevators, terminal railways, cold storage warehouses and shore and floating equipment are particularly affected. The Board is of the opinion that the mounting costs of operation and maintenance are such that certain harbour charges require reviewing and in some cases revision upward as soon as circumstances and regulations permit.

The operations of the Board fall into two divisions: first, the seven harbours administered by local commissioners prior to 1936, and secondly, the grain elevators at Prescott and Port Colborne and the harbour of Churchill, which were entrusted to the Board for operation at the beginning of 1937.

Lighthouses: Especially those on the Coast of Ireland*

Early History

One of the earliest known lighthouses is believed to have been situated in the vicinity of Troy and is mentioned by a Greek poet of about 650 B.C. There are some rather vague references in Homer's Iliad and Odyssey which may refer to lighthouses. Possibly the famous Colossus of Rhodes was used as a lighthouse and must in any case have been a very conspicuous day mark. There is little doubt that the port of Athens, the Piraeus, had several lighthouses in the time of Pericles, c.420 B.C.

The first lighthouse of whose existence there is no doubt was built by Sostratus of Cnidos on the island of Pharos at Alexandria, about 250 B.C. It was built of white marble and is said to have been a hundred and fifty feet high. Fifteen hundred years later it was destroyed by an earthquake. From this tower and island the name Pharos became the general term for all lighthouses.

Thereafter many lighthouses were built throughout the Roman world. The earliest in England, and probably one of the earliest in Western Europe, was built by the Romans at Dover about 44 A.D.

It is very unlikely that anything approaching a regular service was maintained at these old lighthouses. Probably a beacon was lit whenever a ship was known to be approaching port after dark. In days before steam a light ashore was generally looked upon as a warning to keep off rather than an invitation to enter port. The stories of wreckers enticing ships ashore with bonfires probably have little foundation. It is quite possible that lighthouses might have been useful to pirates who infested the English Channel in the days of the Tudors, and that the abolition in those days of lights on points such as the Lizard may have been due to this. In recent years lighthouses were of great assistance to submarines and aircraft for fixing their positions and in all countries many lights were extinguished, the power of those left at work was drastically reduced and the beams were dipped.

The earliest formation of a lighthouse authority in the British Isles took place in 1514, when King Henry VIII founded the "Guild of Fraternity of the most glorious and undividable Trinity of St. Clement," now commonly known as "Trinity House." It received authority to erect beacons for the guidance of mariners. It did not have the sole control of lighthouses as later the Stuart Kings quickly discovered a valuable source of revenue in the sale to private individuals of patents to establish lighthouses. In 1836 Trinity House was given sole charge of the lights of England and the Channel Islands, and the various private lighthouses were compulsorily acquired. For one, the Smalls lighthouse off the Pembrokeshire coast, a sum of about £140,000 was paid to the owners of the patent. Trinity House also controls some West Indies lights and some lights in Ceylon. The lighthouse service of Scotland and the Isle of Man is controlled by the Northern Lighthouse Board. The Irish lighthouses are in the hands of the Commissioners of Irish Lights, whose offices are in Dublin. The service is an all-Ireland one.

The expenditure of these three lighthouse authorities is controlled by the Ministry of Transport. The money is provided by the General Lighthouse Fund from light dues collected at all ports in the British Isles from ships of all nationalities using these ports. The normal expenditure on the Irish lights is about a quarter of a million pounds per annum.

Lighthouse Buildings

The Lighthouse engineer's most difficult task is undoubtedly the construction of the so-called "wave-swept" towers. Of these probably the earliest is at Cordouan, on a half tide rock at the mouth of the Gironde. A large base built on this rock carries a Pagoda-like tower 200 feet high. It is exposed to the seas coming in from the Bay of Biscay, but is in comparatively shallow water and so has not to withstand the attack of the great Atlantic rollers.

The first and most famous of the real wave-swept towers was the Eddystone. This rock is just covered at high water. The first tower, a wooden one, was built by Winstanley in 1698. A year later is was rebuilt and increased in height, but it had only a short life and was washed away during a storm. In 1709 Rudyerd built another tower consisting of a timber skin filled as full as possible with stone. This remarkable work lasted for nearly half a century and in 1759 was followed by Smeaton's first stone building, which set the fashion for all future wave-swept towers. In this tower the stones in each course keyed into each other and also into the stones of the courses below and above, so that it is impossible to remove a stone without removing all the masonry above it. This principle is still in general use. Smeaton's tower was removed and replaced by one designed by Sir James Douglas, F.R.S., in 1882.

The Bell Rock tower off the Fife coast is another fine example of a wave-swept tower. It was built by Robert Stevenson in 1811, and in it the arrangement of floors still in use was adopted. This consists of a ring of great stones forming part of the wall of the tower and cantilevered towards the axis. A circular stone about 6 feet or more in diameter closes the central opening and the whole floor acts partly as cantilever, partly as arch.

Another famous tower of this type is on Minot's Ledge at the approaches to Boston, U.S.A.

Of all the wave-swept towers the finest and most exposed is that on the Fastnet. This rock, 340-ft. long by 180-ft. wide at low water and about 90-ft. high above low water mark, is the higher of a pair of pinnacles which lie close together in the midst of very deep water about 4½ miles south west of Cape Clear. The first Fastnet tower was placed on the summit of the rock and was built of cast iron segments bolted together. Its designer was George Halpin, Engineer to the Port of Dublin Corporation. The cast iron segments were made in Dublin by John and Robert Mallett, my great-grandfather and great-uncle. This tower was completed in 1853. In spite of its height above sea level, it was subject to very heavy blows from the great south westerly Atlantic waves, and fears were entertained for its safety. Following the destruction of a somewhat similar tower on the Calf, a rock at the mouth of Kenmare River, in 1892 it was decided to build a new granite lighthouse tower on the Fastnet.

This tower is based on a very solid portion of the rock in the south west corner. the lowest part being near high water level. The tower is 147 feet in height, the height to the centre of the optical apparatus being 159 feet. Both these heights are measured above high water level. The first thirteen courses, each 2 feet deep, are only partial rings protecting the seaward face of the rock, which is stepped to support them. At 20 feet above high water the tower proper begins, being built of solid masonry to a height above high water of 42 feet. Above this the tower is hollow, the walls gradually diminishing in thickness. The rock itself is formed to a level platform 58 feet above high water and at this level is the entrance to the tower. Above this ground floor are eight floors, varying in height from 9 to 12 feet and in internal diameter from 12 to 16 feet. These floors are of granite and the stairs which spiral round the wall have wrought iron stringers and steps. Most of the granite came from Cornwall. Some from County Dublin was used for filling holes in the foundation and packing between the tower and the rock. The rings were cut and assembled 6 or 8 at a time in the contractor's yard, then taken apart and shipped, the upper ring being retained at the bottom ring of the next set. In this way a perfect fit was maintained throughout the work. The first stone was laid on June 9th, 1899, and the last stone was placed in position on May 2nd, 1903. Working days during this period of nearly four years were 118, which gives some idea of the difficulties facing the lighthouse engineer. Bad weather was the main cause of inability to carry on the work on a greater number of days. Those who have seen the Fastnet in good weather, or for what passes there as good weather, will be able to understand some of the problems which arose.

In all, 4,633 tons of granite were used in the construction of this great tower—one of the finest examples of masonry work in

*** Excerpt from the Presidential Address of Professor J. Purser, M.A., M.A.I., M.Sc., A.M.Inst.C.E., to the Institution of Civil Engineers of Ireland on November 4th, 1946. Reproduced by permission.**

Lighthouses—continued

existence, a wonderful and beautiful sight; 4,600 tons keyed together to form a vast tapering pillar of stone which has stood the worst assaults of the Atlantic for 40 years and still looks as if it had been built yesterday.

The actual cost, including the construction of a special steamer, was £90,000. Allowing for the value of the steamer after completion of the tower and some other items of recoverable expenditure, the nett cost was about £84,000. This works out at about 25s. per cubic foot of masonry, as compared with 39s. for the Bell Rock and 28s. for the Wolf and for the Skerryvore towers. Smeaton's Eddystone tower cost £3 per cubic foot.

The keepers live in the tower. The windows are of very thick plate glass and there are solid metal shutters, which are closed in bad weather. In really bad storms the sea reaches to the lower balcony, 140 feet above high water, and the whole tower deflects to quite a noticeable extent.

On the top of the masonry is a metal lantern which houses a biform first order apparatus arranged in the form of a square. Vapourised paraffin and 35 m.m. triple burners are used and the candle power of the beam is about one million. The remains of the old lighthouse are used as a store and some oil and the fog signal explosives are stored in the present tower.

The other Irish lighthouse stations most interesting to the Civil Engineer are the Bull, Inishtearaght (Outer Blasket), Black Rock (County Mayo) and Rathlin West. The first three and the Fastnet are the great Rocks and the stations are like fortresses, especially Black Rock, a forbidding and gloomy rock rising to a height of about 275 feet and lying a few miles north of Achill Head. In all these stations it is a source of wonder how the

Photograph by Courtesy of Gas Accumulator Co., Ltd.
Rosslare Pier Lighthouse.

mass of heavy equipment was ever got onto the rock. On the Bull there are now power cranes for the first hoist, but the subsequent hoist is by hand winch and the rock is very steep, the path being stepped right to the summit where are the great syren and eight large air vessels each weighing 12 cwts. On Inishtearaght there is a power worked funicular, but on Black Rock, one of the sheerest of rocks, there are only hand cranes. The violence of the sea here may be imagined from the fact that a large crane nearly 100 feet above water on the east or sheltered side of the island was destroyed by a sea in 1942. The post of this crane, consisting of a $7\frac{1}{2}$-in. diameter solid steel bar, was bent through an angle of about 30°. As there were no cranes left on the rock and it was impossible, owing to war conditions, to build a new crane, a light grate was built around the post just below the bend, a fire was lit, and when the post was red hot it was pulled back into the straight by a tackle made fast to a strong-back fitted to the post and to an eye bolt which happened to be fixed in the rock in a suitable position. A new steel jib was landed in small pieces and assembled on the rock and the crane is working as well as ever.

At Rathlin West the main interest is a great expanse of concrete approximately 6 inches thick which protects the basalt slope from weathering and possibly falling on the lighthouse buildings below. The slope is about 1 horizontal to 2 vertical and the area is about 2,000 square yards. This lighthouse was built about 30 years ago and is the most recently constructed important lighthouse in Ireland.

The lighthouses containing the most modern optical apparatus are the Tuskar and Slyne Head. The former is all electric. The power plant consists of three Diesel engines of 8 h.p. each driving dynamos which charge the wireless beacon batteries and provide current for the light. The source is a 3 k.w. gas filled lamp and, owing to the high intrinsic brightness and the small size of the filament, it is possible to obtain a two million candle power beam with a very small lens, one of the third order, of about 20 inches focal length and 65 inches high. This lighthouse was the only one which suffered severely during the war, a floating mine exploding near the entrance to the tower and killing a keeper.

Slyne Head has the most modern type of reflecting optical apparatus, consisting of six Parsons parabolic mirrors of 1,000 m.m. focal length. These are like large searchlight mirrors and are arranged in three pairs 120° apart. The beams from each pair pass through the space between the other two pairs of mirrors. Thus a double flash is given three times during each revolution of the apparatus.

Historically the lighthouse towers at Wicklow Head and the Hook, County Wexford, are the most interesting of the Irish lighthouses. At Wicklow Head the tower at present in service is the third of the towers used there during comparatively recent times. The oldest dates back to the time of open fires in braziers on top of the tower. These three towers are still in existence.

The tower at the Hook was built probably 800 years ago, but a light was maintained there by the Monks of St. Dubhan at least 50 years before the tower was built. The tower is large, about 40 feet in diameter and 80 feet high, divided by three vaulted floors. Inside the very thick walls a spiral staircase climbs to the top, on which a modern metal lantern is now placed. It has been suggested that the tower was built by Eva, Strongbow's sister.

Lighthouse Illuminants

Light was provided in the early lighthouses by bonfires, using timber as a fuel. Then probably followed lamps burning oil, either vegetable or animal; coal fires; candles; gas; vapourised paraffin; acetylene and electricity. The majority of the Irish lighthouses where a regular watch is kept are lighted by incandescent mantles heated by vapourised paraffin, the oil used having a special high flash point. There are a large number of unwatched lights where acetylene is used and a few use electricity.

The chief essential of lighthouse illumination is reliability. Elaborate precautions are taken to obtain this. Spare burners are always in store and at least one burner and several mantles are always immediately available in the lantern. A new burner can be fitted in three or four minutes. In the case of the electric light at the Tuskar the failure of a filament in the lamp causes the lamp holder to move out of the focus of the lens and its place is automatically taken by a duplicate holder and a lamp which lights immediately and reaches full brilliance inside a minute. At the same time, a red light shows and a Klaxon horn blows to warn the keepers who are not on watch. Should the electricity

Lighthouses—continued

supply fail, there is a vapourised oil burner at hand which can be placed in service in a few minutes.

Formerly, coal gas was used at a number of Irish lighthouses. A very large number (up to 108) of bats-wing burners arranged in concentric rings was used. Trouble was caused by smoke, but, by the use of a mica cylinder above the burner, extra air was drawn in above the flames and sufficient oxygen became available to burn the smoke. This indraught of air had the effect of raising the flames and this caused the beam to dip slightly. For these big sources of light, very large lenses were needed. At Bull Rock, on the south west coast—an old gas light—the lenses are 1,330 mm. focal length, arranged in two tiers, the so-called biform light.

The early mineral oil lamps were unsatisfactory, but the invention of the Argand Burner greatly improved the efficiency of these lamps. Later, both Argand burners and coal-gas were superseded by vapourised paraffin burners and incandescent mantles. The mantles are either 50 mm. or 35 mm. in diameter and about the same in height, and give a small and intense source of light with a brilliance of over 480 candles per square inch. In some lights three of these mantles are used in a close group.

The optical system of the early lighthouses consisted of reflectors, generally copper or silvered metal or glass. They were inefficient and their place was taken eventually by the early models of lenses such as are still used in most lighthouses.

The modern lens was invented by a Frenchman, Fresnel. His lens consists of a central plano-convex bullseye and concentric rings of prisms of increasing radius, the whole acting together to produce a beam of light with a divergence of about four or five degrees. The various parts of the lens are generated by rotation of a prismatic section round a horizontal axis in the case of a flashing light, or a vertical axis in the case of a fixed light.

It has been found that the angle subtended at the focus by such a lens should not exceed about 50°. If this angle is exceeded the light passing through the outer parts of the lens is no longer white but blue or green. Consequently the lens was later improved by adding outside the central refracting section a series of totally reflecting prisms. In this way the angle subtended at the focus by the lens can be increased to about 120°, with a great increase of candle power in the beam. In some cases reflectors are used behind the burner which reflect some of the light to the focus and so further increase the power of the beam. This is possible only in lights with certain characteristics.

The effect of the lens is to concentrate into a narrow beam a great part of the light coming from the source. The candle power of the beam from a modern lens can be got roughly by multiplying the projected area of the lens on a plane at right angles to the axis of the beam by the candle power of the source and dividing the result by twice the projected area of the light source. This allows for a lens efficiency of 50 per cent. The candle power so obtained is reduced by 20 per cent. for losses in the glass of the lantern which protects the lens from the weather. A beam of one million candlepower is fairly common and some of the latest electric lights in Great Britain have a candle power of four million. The Tuskar light has a candle power of about two million, with a comparatively small lens of only 500 mm. radius (a third order lens). A first order lens has a radius of about 920 mm. and is a very bulky piece of apparatus. A biform first order lens may weigh as much as four or five tons.

Lenses may have any number of sides. They may be arranged as at the Howth Baily, with two opposite faces like a gigantic oyster shell giving two flashes per revolution. The Fastnet light has its lenses arranged as a square, giving four flashes per revolution. Others may be arranged as an irregular hexagon giving, say, two flashes in fairly quick succession from each pair of lenses, and then an interval of eclipse.

A great variety of characteristics may thus be obtained with ease. The smaller the number of lens panels the greater is the resultant candle power of the beam, but it is found that excellent results are obtained from four and six panel apparatus, and the number of panels seldom exceeds eight.

The early lenses were carried round on rollers running on a metal track. Uneven wear developed fairly quickly and it was only possible to obtain a slow rotation speed with, in consequence, long flashes and very long intervals of eclipse.

The modern lens floats in a mercury bath. Inside an annular trough is mercury, and floating on the mercury is a ring of a cross section very slightly smaller than that of the trough, which is about 12 inches deep. There is a clearance of about three-sixteenths of an inch all round between ring and trough, and the mercury fills this space. The ring supports the lens panels. The

Photograph by Courtesy of Gas Accumulator Co., Ltd.

Coneyburrow Beacon, Londonderry.

pressure due to a head of mercury of about 10 inches is sufficient to support a biform first order lens weighing up to 5 tons, using only about 500 lbs. of mercury. These great lenses can be rotated quite easily with one finger, even started from rest with little effort. They are rotated in service by a weight, the time of rotation being regulated by clockwork fitted with a simple govenor which works like that of a gramophone.

Lights have characteristics of various kinds. The most common are Fixed, Flashing, Occulting, Rapid Flashing or Scintillating, Group Flashing and Group Occulting.

A Flashing light is one in which the period of light is shorter than the period of eclipse.

An Occulting light is one in which the period of light is equal to or longer than the period of eclipse.

A Scintillating light has a very short flash, as many as 60 flashes per minute in some cases.

A Group flashing light has a series of flashes followed by a fairly long period of eclipse, followed by another group of flashes, and so on.

A Group occulting light is similar, but the periods of light are long and the eclipses are short.

A group flashing or occulting light is generally to be preferred to a single flashing or occulting light, as it is more easily recognised, this more particularly at the limit of vision and in a rough sea.

A fixed light is not really satisfactory, as a light in a window of a house ashore may be mistaken for the fixed light. Red or green fixed lights may cause confusion and be mistaken for another ship's port or starboard lights.

The position of a light is of the utmost importance. The first essential is that it should be on, or outside, the point of danger. It must be visible from as big an arc as possible, it should be close to the sea and it should, if possible, be at such a height that it can be seen from great distances, but should not be so high that it is liable to be eclipsed by low cloud. There are some lights which become invisible from this last cause, though the visibility near sea level is excellent. The light on Cape Clear

Lighthouses—continued

Island suffered from this trouble and was discontinued and the lighthouse on the Fastnet took its place.

The main landfall and departure lights of Ireland are the Old Head of Kinsale, the Fastnet and the Bull off the south coast, and Aranmore, Tory Island and Inistrahull off the coast of Donegal.

Of the coastwise lights, the Tuskar is the most important, followed closely by the Rathlin lights, Mew Island (one of the Copeland Islands off the mouth of Belfast Lough) and Howth Baily.

A complete list of the more important coastwise lights is as follows:—Howth Baily, Wicklow Head, Tuskar, Hook Point, Ballycotton, Galley Head, The Skelligs, Inishtearaght (Outer

Photograph by Courtesy of Gas Accumulator Co., Ltd.

Guide Bank Beacon, River Suir, Waterford.

Blasket), Loop Head, Aran South, Aran North, Slyne Head, Clare Island, Black Rock Mayo, Eagle Island, Rathlin O'Beirne, Rathlin West, East and Rue, Maidens, Mew Island, St. John's Point, Haulbowline (Carlingford Lough), and Rockabill.

In addition, there are a large number of smaller lights maintained by the Irish Lights Commissioners, some watched and some unwatched, and many lights maintained by local authorities and harbour boards.

The so-called unwatched lights run on acetylene and are looked after by a local attendant, who sees to the emptying out and recharging of the gas generator at fortnightly or three weekly intervals. The light is sometimes extinguished during the day, in other cases it runs continuously. The gas generator used by the Irish Lights is of considerable interest and is rather unusual. Carbide is fed automatically from a hopper as required into a large cylinder containing about three feet depth of water. When the grain of carbide enters the water, gas forms all round it and decreases its effective density to little more than that of water and in consequence it sinks very slowly. As the grain sinks it gives off gas which is effectively washed and cooled as it rises. Because of the low temperature, the gas is nearly pure acetylene and not the mixture of gases obtained in the usual generator when water is added to a mass of carbide. The gas, strangely enough, is very dry when it leaves the generator. It passes over a pair of superimposed trays, each carrying a layer of carbide, and is there dried still further. It is then filtered by passing it through a thick layer of felt and finally through a vessel containing a strong solution of Chromic acid in Kieselguhr, containing about 136 grams of acid per kilogram of absorbent. This removes practically the last traces of phosphorous and sulphur. It is now a clean, dry gas, without objectionable smell and burning without any burner trouble for months on end, even when used in tiny pilot jets.

The use of such lights has enabled great economies to be effected in the case of many of the less important lights. The flashing apparatus used is a modification of one invented by a German—Pintsch—improved by the Swedish A.G.A. Company, and now manufactured, including further improvements, in the Irish Lights Workshops at Dun Laoghaire.

The burner apparatus enables various arrangements of light and eclipse to be made by a simple exterior adjustments.

The lightships have been mentioned already. These ships keep a constant watch and show a light at night and a day mark and have sound signal apparatus for use in fog. They are anchored in position with a heavy anchor and a great length of heavy chain and very seldom shift their moorings. They are roomy ships about 100 feet long, 25 feet beam and 10 feet draught. They carry a crew of 10 or 11 men. They are in several cases very old ships, the oldest having been in service for 53 years. They are mostly constructed of wrought iron or steel, but some are composite, having steel frames and timber hulls. These latter are sheathed with Muntz metal or naval brass. They are very well looked after and make comfortable, if rather lively homes for their crews. Their upkeep cost, including crew's wages, is considerable, about £4,000 per annum per ship.

The Kish ship has a lantern using incandescent mantles and vapourised oil, and the reflectors are parabolic silvered glass, rather like searchlight mirrors. This apparatus gives a very good and powerful light.

The Daunt's Rock Ship is fitted with a radio beacon. The Kish Ship will soon be fitted in a similar manner, also the South Rock Ship.

Sound Signals

Nowadays these are given by syrens or diaphones worked by compressed air, or by the explosion of small quantities of tonite by electric detonators.

Syrens and diaphones are somewhat similar machines. In the syren, the valve controlling the passage of the air to the trumpet is rotated about the longitudinal axis of the trumpet either by the pressure of the air or by outside mechanical means. In the diaphone the valve moves endwise in the trumpet and its movement is controlled entirely by the air supply. An air operated syren has a note of gradually rising and falling pitch, a mechanically operated one can be run up to a speed before the air valve is opened and so produces a note of constant pitch. The diaphone produces a note similar to a syren, but the blast finishes with a pronounced low note called "the grunt," which enables the diaphone to be distinguished from the syren. Those who live within range of the diaphone on the East Pier at Dun Laoghaire have ample opportunity of becoming familiar with the sound produced by a small diaphone. The air consumption in this case is only 1 cubic foot of free air per second of blast.

The most recently installed syren in the Irish Lights Service is on the Bull Rock.† It consists of three large super-imposed trumpets arranged at angles of 120° to each other and pointed to a common centre. The syren is of the mechanically operated valve type, so it is possible to run all three valves from one shaft

†"Navigational Fog Signals," J. W. Tonkin, Trans. Inst.C.E.I. LXVI, 1940.

Lighthouses—continued

at exactly the same speed. The three trumpets thus emit notes of the same pitch and produce a very smooth sound. This syren gives a fine all round signal, consumes 81 cubic feet of free air per second of blast, and has been heard in Killarney about 50 miles away.

Explosive signals are used at many lighthouses. Running costs are high but engines for providing compressed air are not required, nor are large air receivers and a variety of other gear. The charges used are generally tonite. They are fitted with detonators before attaching to the firing jibs, and the detonators are fired by an electric battery. The current passes through contacts which are only made when the jib is in its firing position, and so it appears to be quite impossible for the charges to be detonated when the keeper is fitting them to the jib. At least two cases, however, have occurred when the charge has been exploded by lightning with the contacts open. A clock in the firing house rings a bell at the moment for firing, the keeper presses a key and the charge explodes.

In some places aluminium is added to the high explosive and, in addition to the noise, the charge, when it explodes, gives a vivid flash. This combined sound and flash signal is very popular with sailors, but unfortunately the cost is very high, about 2s. a charge, and, as charges may be fired at minute intervals over long periods, the cost quickly mounts up. The ordinary tonite signal costs about half the above figure. The maintenance cost of a plain tonite signal firing at 5 minute intervals is approximately equal to that of a first class diaphone sounding every minute.

Signals of the flash-sound type are made by the Kish Lightship and at Hook Point.

Radio Beacons

In recent years many radio aids to navigation have been developed. Radio time signals render chronometer unnecessary except when the wireless gear breaks down, when the clock comes into its own again.

Radio beacons have been in use for many years. They are of four kinds, though only one type is in common use for sea navigation.

In the first type, a ship sends out a radio signal. Two stations on shore determine the bearing of the ship by means of directional aerials. The position of the ship is worked out and sent to the ship by wireless. The operation takes some time and the sailor has to accept responsibility for the information, and if it is inaccurate has to take the blame for any accident that may occur. This type is now obsolete.

In the second case, a group of three wireless stations send out coded signals one after the other, usually at two-minute intervals. The ship, by means of its own directional receiving gear, determines the bearing of the stations and so can plot its position with reasonable accuracy. This can be done every 30 minutes or every 6 minutes in fog. The transmitting stations of each group send on the same frequency. For instance, one very important group consists of the following:—Mull of Cantyre G.G.C., Tory Island, E.I.B., and Eagle Island (Co. Mayo), E.I.F. The wave length is 1,008 metres. G.G.C. transmits at 6 minutes and 12 minutes after each hour and half hour, E.I.B. at 8 and 14 minutes, and E.I.F. at 10 and 16 minutes. The Irish call sign is not a very satisfactory one. E.I. in morse code is a very short signal, G.G. on the other hand is a relatively long one. To counter-balance this defect, the signal sent out by the Irish stations consists of groups of dashes, a definite number in each group for each station. For instance, Tory Islands sends for its complete signal the following:—E.I.B. four times, groups of 11 dashes for 40 seconds, E.I.B. twice, the total time being one minute. After a silent interval of one minute, Eagle Island starts up with E.I.F. four times and groups of five dashes for 40 seconds, followed by E.I.F. four times, groups of five dashes for 40 seconds and E.I.F. twice—total time, 1 minute 40 seconds. The Mull of Cantyre sends a series of G.G.B. for about 40 seconds followed by a continuous note for about 10 seconds and repeats this series, the whole transmission lasting 1 minute and 40 seconds, as in the case of Eagle Island. Tory Island will shortly transmit a signal lasting 1 minute and 40 seconds. Anyone who can count up to eleven can distinguish the Irish Stations. A knowledge of the morse code is not really needed.

Types three and four are rotating beams used for aerial navigational purposes only. These are now obsolescent.

In the last year or two, another aid to navigation has been developed. This is Radar, of which so much has been heard lately. It has unlimited possibilities as a navigational aid, but needs much simplification before it comes into general use in the Merchant Service. It is still a tool for the specialist. Radar enables the sailor to see on a fluorescent screen any object large enough to reflect the very shortwave length beam sent out from the ship's transmitter. It is possible to see on the screen a map of the nearby land, and, by means of a chart drawn to a suitable scale, to fix the position of the ship and the direction in which it is heading. Also to fix the position of ships, buoys, aeroplanes, etc., within range of the radar set. This range at present is about 20 miles for ordinary marine use. It is now possible to pilot a ship "blind" up such narrow and tortuous channels as the approach to Portsmouth Harbour, and to keep clear of other ships using the channel. The use of Radar for navigation is at present confined to shipboard, but it is probable that it will be developed for use in the lighthouse service eventually.

There is another radio aid, using transmissions from three long-wave stations which enables the navigator, with the help of a special receiving set, to fix his position with great accuracy at ranges up to 200 miles from the transmitters, while good accuracy has been achieved at 1,000 miles. During the war the navigation of the Schedlt from the sea to Antwerp was maintained by means of this system, in spite of the frequent fogs for which this waterway is notorious.

The personnel of the lighthouse service deserve some mention. They are a fine reliable body of men, on whose work so much of our civilisation depends, and whose duties are at times very monotonous and fairly arduous.

The keepers are provided with dwellings for themselves and their families, or a lodging allowance is made in some cases. Keepers on rock stations live in shore dwellings when off duty and are paid a special allowance when on the rock to compensate them for being separated from their families and for the hard living conditions on the rock. The normal rock station routine is six weeks on the rock and two weeks ashore, but, especially on the western rocks, turns of duty may be extended to ten or twelve weeks in very bad winter weather.

A keeper, who must have put in some time at sea or have a trade, is appointed first as a keeper on probation, then as assistant keeper, and finally as principal keeper. He retires at the age of 60 with an annual pension and a lump sum gratuity. There are a few stations which are looked after by a keeper near the retiring age and his wife. These are known as single stations and are eagerly sought after by the senior principal keepers. The total number of keepers is at present 146. There are also 19 attendants who care for the "unwatched" lights.

From what has been said, it will be clear that the lighthouse engineer's work is interesting and very varied. In addition to building and maintenance of lighthouses and dwellings, he must be thoroughly conversant with the laws of light and sound. He must be a mechanical engineer with knowledge of internal combustion engines, antique and modern, of cranes, winches, etc. He must be able to construct and keep in repair clocks and apparatus driven by clockwork. Of late years he has had to become a radio engineer and have a good working knowledge of radio transmitters with powers up to a kilowatt, and of radio receivers. His work is partly routine, but he never gets into a rut. He has to be a jack of all trades and master of each. He is at constant war with sea and wind and rain, and his life is certainly never dull. Much of his work is done in the office, but he has many opportunities of getting out on the job in places where he can see the loveliest as well as the most savage side of nature. His is, indeed, an existence which many might envy.

Notes of the Month

Dunkirk to be Reopened.

It is announced that the Port of Dunkirk will be reopened for shipping in October. During the war the Germans sank 20 vessels in the harbour and blew up the dock gate. All wrecks have now been removed and a new dock gate is expected to be ready by the end of this month.

Timber Facilities at Amsterdam.

The Amsterdam Port Authority has announced its decision to build new facilities for the storage and discharge of soft and hard timber near the Minerva Harbour. It will be necessary to dredge a deeper channel in the present fairway, and quay walls will have to be built, and travelling cranes provided. The cost of these improvements is estimated to be 7,000,000 fl. and the work is expected to take 18 months to complete.

New Shipyard for Karachi.

John Brown & Co., Limited, Clydebank, is to give technical aid to the construction of a new shipyard at Karachi, in association with Sir William Arrol & Co., Limited, engineers and bridge builders. The yard is to be built within two years at an estimated cost of Rs. 50,000,000. It will have three or four berths and be capable of producing ships of up to 15,000 tons. The latest technical developments to be used in its construction will include prefabricated workshops.

Train Ferry Connection with Germany.

A new train ferry connection between Sweden and Germany has recently been opened. The initial trip on the new route, between Trelleborg in South Sweden and the German Port of Warnemünde, was made on June 1st last by the Swedish train ferry *Konung Gustaf V*, which carried 18 goods trucks laden with granite, cell wool, chemicals and other goods, mainly bound for Czechoslovakia. No fixed time table has been arranged so far, the ferries sailing as soon as a suitable number of goods trucks have been assembled in the ferry ports.

Decca Navigator System for Sweden.

The Decca Navigator Company, Ltd., announce that they have secured from the Swedish Government a contract for the supply of a complete Decca Navigator system comprising three transmitting stations and marine receivers for the purpose of hydrographic survey in Sweden and the surrounding seas. This is the second contract of this type obtained by the company within a year, a similar system having already been supplied to the Danish Government. A chain of special radio stations enables the survey ship equipped with the Decca Receiver to fix accurately her position throughout the whole period of her survey work.

Decasualisation of Dock Labour in Northern Ireland.

The Northern Ireland Ministry of Labour and National Insurance states that the Committee appointed to enquire into the possibility of decasualisation of dock labour in Northern Ireland have made their report to the Minister of Labour and National Insurance. The Government has given preliminary consideration to the matter and has accepted the principle of decasualisation provided an economical scheme can be worked out within the industry. The Committee recommend the introduction of a scheme of decasualisation embracing the ports of Belfast, Londonderry and Newry. They propose, as a condition precedent to the introduction of a scheme, that sufficient and no more than sufficient dock workers to deal efficiently with the trade of the ports should be admitted to the Port Register, and that the numbers should be determined by a Committee of employers' and workers' representatives at the ports concerned. The scheme should be self-supporting, and workers are to be guaranteed a minimum wage of £4 5s. per week, all earnings, including attendance money, overtime and week-end earnings, being set against the guaranteed wage.

Tidal Model of Tay Estuary.

A tidal model of the Tay Estuary from the sea to Perth, more than 30 miles upstream, is now ready for use at Dundee Harbour. It is hoped to obtain valuable data about changing currents, sandbanks, etc. The model, which is believed to be the most ambitious of its kind in the country, is being demonstrated to visiting scientists during the visit of the British Association to Dundee from August 27th to September 3rd.

Opening of New Port on Arabian Coast.

It was recently announced in *Lloyd's List* that a new company the Trans-Arabian Pipeline Company, has been formed to build a 30-31-in. pipeline from the Persian Gulf to the Levant. The eastern terminal of the pipeline will be at Ras al Mishaab, on the Arabian Coast, about 80 miles south of Koweit, just south of the Neutral Zone (in approximately 28 8 N., 48 40 E.). The first ship to call at Ras al Mishaab, was the Norwegian motor ship *Hoegh Silverbeam* (7,707 tons gross) which arrived during the middle of last month. The new port will eventually become very busy, as it will handle all material for the eastern section of the pipeline.

Free Ports Proposed for Italy.

In connection with the increase in steamship sailings from Italy to overseas ports, both under Italian and foreign flag, the creation of free ports has been discussed. According to proposals put forward by the Chamber of Commerce of Genoa, this would include a special currency regime, outside the control of the Italian Treasury, to facilitate the financing of traffic through any free port. It is likely that a free port at Genoa will become a reality before next summer. The Chamber of Commerce at Leghorn is also pressing the Italian Government for free port facilities there. It would appear that there are important American interests behind this move, with plans to exploit the concession to establish assembly works of American factories at Leghorn.

Port of Rotterdam Quay Sheds Rebuilt.

The Burgomaster of Rotterdam recently opened the reconstructed sheds of Corn. Swarttouws Stevedoring Company in the Merwehaven. The new sheds have a surface of 9,000 sq. m. (97,000 sq. ft.), and a very modern ventilation system regulates the temperature and humidity of the air. Great care has been taken to provide against fire risk, for which a sprinkler installation has been constructed in the sheds. In winter time heated air and in summer time cooled air can be blown into the sheds in order to create any temperature desired. Modern equipment, consisting of 14 level luffing and 4 floating cranes assures a quick handling of the cargo.

Polish Maritime Institute.

The Polish Maritime Institute, Ltd., has been registered as a company limited by guarantee, without share capital. The original number of members is 100, each liable for £1 in the event of winding up. The objects are to establish an organisation for founding nautical schools, workshops, etc., ashore and afloat, for the benefit of Poles outside Poland and also to encourage friendly relations between Poland, Great Britain and other nations in maritime matters, etc. The Board of Governors are: Dr. T. Brzeski, Dr. T. Bugayski, Mr. J. J. Campbell (Glasgow), Sir Patrick Dollan (Glasgow), Mr. T. Dzieszko, Official of Committee for Education of Poles in Great Britain, Rear-Admiral K. Korytowski, Mr. J. Kozuchowski (former Vice-Minister of Industry, Commerce and Shipping, etc.), Mr. L. Mozdzenski (former Director of Maritime Department of Ministry of Industry, Commerce and Shipping), and Dr. S. Z. Szyszkowski-Szydzowski, Director of School of Foreign Trade and Harbour Administration, London. The registered office is at 24, St. Mary Axe, London, E.C.3.

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Technical Committee's Third Term of Reference*

(Continued from page 108)

The third term of reference to the Committee reads:—"What steps are necessary to develop minor ports in order to meet probable demands of coastal shipping traffic? In taking up this reference, the Committee was immediately faced with the problem of determining the best course to adopt in order to answer the question put to it. There are nearly 200 minor ports on the Indian Coast, not counting those within the borders of Indian States, and it was obviously not practicable to visit every one or even a large proportion of them and detail the steps to be taken to devolop each one. The Committee, therefore, decided to treat the subject in a more general way and to try and indicate the manner in which the development of the ports should be undertaken on broad lines. In this part of their task the Committee has had before it the Planning and Development Reports of the Maritime Provinces and the proposals made by Indian Maritime States for the opening up of their own coasts to sea trade. It has been also the applications of various commercial bodies and of private parties for consideration of individual ports and port-projects. Each of these is dealt with in its place. Many minor ports are not susceptible of much improvement owing to natural disadvantages such as unstable sand banks, the vagaries of river channels and the often incalculable forces of ocean tides and currents; many ports, which once were prosperous, have become back waters of trade, the bulk of which has gone elsewhere with the changes in distribution of population; many of them have been ruined as they have been allowed to silt up owing to the policy of the railways, many have retired into obscurity because trade has been to a large extent concentrated on the seven major ports which have road or rail or canal communication in every direction, and facilities far beyond the means of the exposed coastal anchorage or a small creek. Quite a few, however, in spite of poor facilities have carried a large tonnage of cargo which has continued to be routed through them owing to their favourable geographical position and comparatively low cargo charges.

The Maritime Provinces and States.

The maritime provinces are five in number, Sind, Bombay, Madras, Orissa and Bengal; and the coast states are those of Cutch, Kathiawar and Travancore. The Committe began by referring to the Planning and Development programmes of the above Provinces and then proceeded to interview the Governments and States concerned who had in view schemes of improvement for their minor ports. Of the Provinces, Sind and Bengal had no proposals of sufficient magniture to put forward, while Orissa had only one for the improvement of Chandbali near Cuttack; Bombay had no specific case to press but wished to offer general suggestions; Madras, on the other hand, has a substantial port-development policy. The Committee, therefore, decided to concentrate its investigation on the two provinces which were most interested in their littoral sea-trade and where the successful use of the small harbour facilities along the coast is of definite inportance to the economic future of the country; these two provinces are Bombay and Madras. As regards the maritime states, proposals that have been made have already been dealt with under the appropriate headings.

Government Policy in Shipping and Railways.

At a very early stage it became apparent to the Committee that the future history of the minor ports is linked with the Government's policy in respect both of shipping and railways and dispersal of industries. We cannot say that now we will settle the future of the minor ports and shut our eyes to their connecting links with the rest of India. It has been said many times that a port is a gateway through which trade passes from sea to land and vice versa. A minor port can be likened to a postern or a wicket-gate, not of so much importance as the main entrances, but yet performing a definite service, and that service clearly dependent on ships on one side of the gate and railway trains and road connections on the other.

If Government are resolved that the sea path round the Coast of India is to be put to its best possible use it is not only necessary that ports, major and minor, should be fitted to pass the trade, but also that steps should be taken to rationalise the means of transport both by sea and land and discourage in the national interests of the country any unfair and uneconomic competition on the part of either. Should considerations of high policy require that the railway lines running parallel to and close to the coast all the way from Calcutta and Tuticorin should be used to their maximum carrying capacity, as to all intents and purposes they have been in the past, ignoring the necessity of maintaining and developing the comparatively cheaper form of transport by sea, then the character of the eastern coastal ports need not be changed. They have their trade now, not very great, apart from coal and groundnuts, and can be content with small improvements such as every undertaking requires to keep alive and abreast with the times.

The present carriers of trade, i.e., large or moderately large ships up to 5,500 gross registered tons that lie well out in the roadstead and the small sailing craft of 50 to 100 tons that nose their way into the creeks are the best medium for coastal and even foreign trade requirements at minor ports. If deep water berths and channels are to be provided for such ships, they will be both difficult and costly to maintain and will need a large trade to pay for them. At the present time the Government who have the minor ports in their charge have, therefore, not considered it their duty to carry out such large improvements to these ports. The Government of India have, however, announced in their latest policy that they want to develop national shipping. If such shipping is encouraged and developed and if railways are laid out with a view to feeding these minor ports, the Government will have to consider whether in those circumstances it will become a practical and economic proposition to provide deep water berths and channels for shipping at such ports. Till that time shipping will have to put up with the existing conditions and to continue work in the roadstead as it is doing at present.

Sand Movement.

It is desirable to emphasise that, while minor ports of the present type, consisting of roadsteads for ships and creeks or estuaries for lighters and sailing craft, are cheap to maintain and can deal with a quantity of trade, a little roughly perhaps, but still with reasonable speed and safety, the next development, the deep-water channel and quay berth, is not necessarily feasible at any minor port except at great expense, and any scheme for such work requires very expert engineering advice and a sure trade return, for it will cost money.

The trouble is mainly sand-movement. This, on the East Coast, takes the form of what is known as littoral drift, and on the West Coast, the periodical silting up of channels, which means dredging—that bugbear of harbours—and the blocking of harbour entrances.

The littoral drift on the East Coast requires explanation. It is a widely accepted view that the East Coast of India is an eroding coast, being exposed to the prevailing ocean current which beats northwards from Australia, and that the sea has a tendency to encroach on the land. This sea-action is counteracted by the accumulation of silt brought down to the coast by the big rivers, the Mahanadi, the Godavari, the Kistna and the Cauvery. The silt from these great rivers, being washed northwards up the coast by the South West Monsoon and down the coast by the returning North East Monsoon, replaces the soil eroded by the sea and so maintains the coast line in a rough equilibrium. Where, however, the coastal flow of silt and sand is obstructed, as for instance by a groyne built out from the coast line into the sea, the sand tends to accumulate on one side of the obstruction and the natural

*Summarised Abstract of the Report prepared by the Ports (Technical) Committee and submitted to the Government of India in May 1946. A Summary of the Committee's recommendations was printed in the February 1947 issue of this Journal.

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erosion to continue in an aggravated form on the other side. This, briefly, is the sand-travel problem about which so much has been written. This is the problem at Madras, now, it is hoped, approaching solution, and a similar problem exists at Vizagapatam which is still not completely solved.

There is reason for thinking that at any point on the East Coast where an attempt is made to lay a deep-water harbour capable of taking large ships, this sand-travel bogey will have to be faced. The development, therefore, of any minor port on the coast into a major one depends first of all on answering the question how to design a deep-sea basin with a deep-sea entrance and then how to keep that entrance clear of the coastal sand-drift.

In conclusion, if it is desired to change the character of the minor ports on either the East or West Coast, to convert them from roadsteads with small craft facilities in shore into sheltered harbours in which ship of 1,000 tons and upwards can lie against a quay, a maintenance dredging problem has inevitably to be faced and sufficient trade has to be developed to cover the dredging costs. Railway and shipping policy hitherto followed does not encourage this change in the minor ports.

PORTS OF THE BOMBAY PROVINCE.

There are 75 minor ports in the Bombay Province, 25 of which or north of Bombay and 50 to the south. All these ports are very small in size and vary in importance from Broach which handles traffic worth about Rs. 88 lakhs in the year and Ratnagiri Rs. 62 lakhs, down to a little port such as Vijaydurg which deals with traffic worth only about Rs. 12 lakhs. The ports north of Bombay have to compete with the B.B. & C.I. Railway which follows the coast line closely from Bombay to Broach. The ports south of Bombay on the other hand suffer from having no railway communication to bring them traffic, the railway passing 50 to 100 miles inland.

It seems likely that the alignment of the B.B. & C.I. Railway along the coast will prohibit any large development of the ports north of Bombay for coastal traffic. On the other hand it is possible that road development, if and when made, may bring more trade to the coastal ports south of Bombay.

Bombay minor ports are not used for foreign trade to any appreciable extent, thus differing essentially from the ports on the East Coast of the Madras Presidency with their groundnut trade.

The report of the Bombay Minor Ports Committee appointed in 1937 holds out no hopes of any substantial development of the minor ports and no more recent proposals than those of that Committee have been made. Further, no minor port schemes of importance are included in Bombay Post-War Reconstruction and Development plans.

General Proposals for Improvement.

Members of the Committee were, by the courtesy of the Bombay Steam Navigation Co., given the opportunity of visiting some of the southern ports by sea, and the Bombay Government kindly permitted the Collector of Central Excise and the Deputy Superintendent of Lighthouses to accompany them. In the course of discussion with these officers the following points emerged as worthy of consideration:—

(a) It may be reasonably accepted as a matter of long-term policy that all minor ports of the Province should eventually be capable of taking close inshore sea-going power launches of maximum 8-ft. draft and sailing vessels of maximum 10-ft. draft with or without auxiliary engines.

(b) Practically all the minor ports are capable of dealing with craft of the above description or can be enabled to do so at comparatively small expense. Such craft should be able to work their cargoes alongside jetties at Gogha, Kavi, Broach, Surat, Bulsar, Bilimora, Navsari, Dahanu, Bassein, Varsova, Revdanda, Bankot, Dabhol, Ratnagiri, Devgad, Achra, Vengurla, Redi, Karwar, Tadri, Ankola, and Honavar. While, however, the works required to meet the above standard are small, without them coastal traffic is not adequately provided for.

(c) It is desirable that oiling and watering facilities of some kind should in due course be provided at principal minor ports, but this may prove a serious difficulty at some of them, and a priority programme of work will need to be drawn up.

(d) Apparently at these minor ports there is no specific charge on cargo, distinct from the charge on ships. This is a little difficult to understand, as port facilities should as far as possible be paid for by the trade using the port, and a very small charge should enable Government to improve the cargo-working facilities on an economic basis.

(e) Tonnage statistics are required for all the ports. It is not possible to make sound and balanced decisions without comparable figures of trade at each, and dead-weight tons generally provide the best comparison here as at major ports.

(f) No development of the minor ports for strategical purposes in order to obtain dispersal of port capacity and cargo risks seem possible owing to the small size of the ports.

(g) It should, finally, be realised that the Bombay Government are not anxious to initiate a policy of minor port improvement until the road-rail policy of the Government of India is more clearly defined.

Passengers.

An outstanding feature of the Bombay minor ports is their passenger traffic, the reason for this being the absence of road and rail facilities in the coastal area. For example, quoting from the Minor Ports Committee, Ratnagiri handled about 133,000 passengers in 1936-37 and Devgad in the same year about 81,000. Last year, 1944-45, the passenger figure on the coast was about two million. In the years before the war over 600,000 passengers were transported annually from Bombay itself to the minor ports in and near the Bombay harbour while about a million passengers were carried from Bombay and the minor ports outside the harbour to the minor ports south of Bombay. In addition, about 200,000 passengers were carried from Bombay and its minor ports to other ports outside the Province.

These are by no means negligible figures, and the Committee was pleased to be given the opportunity of seeing how these passengers are dealt with at some of the ports, including Ratnagiri. The conditions are not ideal. The boats to convey passengers between ship and shore appear well suited for the purpose, but at some ports, and even at Ratnagiri, when occasionally rough weather prohibits the use of the jetty, passengers have to wade through the sea between boat and beach. The half-dozen ports that the Committee members visited are well-served by road and road transport, though lighting at and in the neighbourhood of the port is extremely poor. The accommodation for waiting passengers, except at Ratnagiri, is on the small side and should be enlarged; the same remark applies to the sanitary conveniences.

In making these criticisms we do not, however, forget that improvement schemes have been held up by the war. Also the passenger season does not extend into the monsoon and therefore normally fine weather is enjoyed by passengers embarking and disembarking. The use of pontoons for landing passengers at small ports has been advocated and seems feasible. They are said to be obtainable from military disposal sources and are thus described in a note received from the Deputy Superintendent of Lighthouses, Bombay:—

"Built of steel tanks complete with joinery fittings, etc.,; the buoyancy tanks are $\frac{3}{8}$-in. thick, 7-ft. long, and 5-ft. square. They are joined together with suitable steel bars and gimbles either sideways or end on. The upper surface of the pontoon where these tanks are joined together gives a level walking surface and in very hot weather it is possible to fasten a wooden deck as a heat-resisting remedy. These pontoons are fitted at various sections with gimbles enabling the pontoon to slightly bend on a gentle rise of the swell. The fittings are arranged to enable any formation of the pontoon to meet local conditions; e.g., a "T" end can be made by taking the end section and fastening it across the end of the pontoon, or the full pontoon can be widened by disconnecting in the middle and fastening the two sections side by side; in fact, any shape and formation can be made.

The Landing and Wharfage Fees Fund Committee, Bombay, proposes to use pontoons for landing of passengers at minor ports where landing on the foreshore is difficult. They will be securely moored in such a way as to enable the passenger tarafas to come

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alongside and step on to the pontoon and walk to the landward end where a ramp is connected to that end of the pontoon. This will enable the passengers and their baggage to land fairly high up on the beach.

Minor Port Policy.

In conclusion, the Committee would emphasise that nothing is to be gained by considering port development on the West Coast, except for the small improvements desirable in the interests of the passenger traffic. At present the ports South of Bombay are far from the railway and, with their natural disadvantages, are not capable of development because there is no traffic to justify sehious expenditure on them. This is not a case in which the port facility will produce the trade; it is rather one in which road construction may do so and we must wait for that to come first.

Conservation of the Coastline.

Reference has been made to Sand Movement. Some of the Bombay minor ports suffer severely from silting or erosion. A clear example of the former is at Vengurla, where the old Customs cargo jetty is no longer accessible to cargo boats except at high tide owing to the silting up of the bay. At Ratnagiri there is a striking example of erosion, where rapid incursion of the sea, aided by the river, is taking place, and fallen trees and ruins of walls and buildings litter the foreshore. No effective steps have been taken to arrest either the one or the other and it is clear from the 1937 report on the minor ports that several other ports are similarly affected by natural changes.

The Committee feels that this is a matter of some importance, greater perhaps than should be left to Provincial Governments, who may, or may not, be fortunate enough to have at their service expert engineering advice, and other resources, which will enable them to deal correctly with their coastal silting and erosion problems. The matter left in inexperienced hands can easily become disastrous, as it bids fair to do at Ratnagiri, unless something is done there without delay. The Committee, therefore, recommends that the conservation of the coast line of India should be the direct concern of the Central Government.

MADRAS MINOR PORTS.

There are 100 minor ports in the Madras Province, 41 on the West Coast and 59 on the East, and these present a very different picture from that of the Bombay ports. In the first place, while Bombay has a comparatively narrow littoral strip between the Western Ghats and the sea the coastal area on the East Coast of India and that part of the West Coast which is in the Madras Province is very much broader, more cultivated and more thickly inhabited.

The first question discussed was whether the Madras Government anticipated any change in the class of ships now carrying the coastal trade of the Presidency through the minor ports. The Presidency Port Officer said that he was under the impression that ships of 500 to 1,000 tons were likely to be put into service for this trade, and that he had received a request from one of the Oil Companies for information as to whether craft of 10-ft. draft could be taken at the ports of Masulipatam, Cuddalore, Negapatam and Tuticoran. It may be noted that craft drawing 10-ft. can lie in the canal at Cocanada where bulk oil is discharged from barges.

The Committe itself has no information that a change in the class of ships performing coastal services is contemplated and it is assumed that the coastal service at least in the near future as in the past, will be maintained by large coasting steamers which lie out in the roadsteads, and cannot approach very near the shore, and by small sailing craft which can pass over the bars at various ports and do their work at jetties in sheltered water inside. Similarly lighters can also work at these jetties and carry cargo between them and the ships in the roadsteads.

Natural Handicap of the Eastern Ports.

As already stated, the littoral sand-drift is the bane of the East Coast. It is this which prevents the natural growth of the ports. So long as a port consists of a roadstead with shallow-water jetties inshore, as at Cuddalore and Masulipatam, or with open beaches, as was, in the old days, the case at Madras, nature does not interfere. As soon, however, as an attempt is made to bring the deep sea close inshore, and to confine it between walls, the sand makes trouble. It has spread along the south side of Madras Harbour and at one time threatened the entrance; it makes the expense of maintaining useful jetties for deep ships at a very small port prohibitive, and only large trade can justify it. Unless, therefore, there are clear prospects of vastly increased trade at places like Cuddalore and Negapatam, such ports must remain as small ports, content with the primitive carriage of cargo by lighters between the shore and ships lying at anchor well out to sea. The Committee, however, suggests that suitable steps be taken to maintain the approaches up to a proper standard. Under this category must be included the Port of Chandbali near Cuttack in Orissa. Here the Government propose to spend Rs. 10 lakhs on port improvement, but the port will remain a small port and nothing can be done, except at crippling expense, to make it anything more. It is the same natural sand-action that caused the nearby port at False Point to be abandoned, though at one time it appeared to be a natural harbour.

West Side of Alexandra Dock, Bombay.

Accepting the possibility that a change in the future size of coasting steamers might materialise, the Government of Madras planned to obtain two dredgers at a cost of roughly Rs. 80 lakhs in order to keep some, at least, of the ports open for the working of ships of 18-ft. draft, or something like it, at jetties and quays on the coastline. As already pointed out, however, there is nothing to show that such a change in the type of ship employed is mooted and so this expenditure will be saved, but it is quite certain that, if it were found desirable to carry the coasting trade in small coasters drawing about 18-ft., a very heavy dredging commitment would have to be met on the Madras coast.

Works Proposed.

The Committee discussed the Madras Government's proposals with the Government representatives.

(a) **Cocanada.**—Government have prepared plans for spending about Rs. 6½ lakhs at this port, the chief items being the reconstruction of the Dry Dock (120-ft. long for dredgers, etc.), expected to cost Rs. 1,80,000, the re-alignment of the wharf walls at a cost of Rs. 1,20,000 and thirdly the construction of a masonry retaining wall on the north bank of the Commercial Canal. There are also other proposals of smaller importance. The Committee agrees that the works seem to be sound and should be undertaken.

(b) **Masulipatam.**—The Government have planned to spend Rs. 4,70.000 on improvements to the new bar channel at this port and the work is given priority in the list of works on minor ports. The

A Survey of Indian Ports—*continued*

trouble with the bar channel is that it is now liable to shift as much as 3,000-ft. in some seasons and this makes lighterage work a matter of difficulty. At this port, ships lie over 5 miles off-shore, cargo being conveyed to and from them by means of lighters. The wharves are situated at the head of a creek which is very tortuous, so that the distance from them to the mouth of the creek is nearly 7 miles. Three or four years ago a new bar channel was dredged so as to shorten the distance from the wharves to the mouth, but while this improved conditions in the channel, it failed in its prime object, owing to the effect of the littoral drift, which caused the new mouth to travel steadily northwards, so that it is now 2,600-ft. north of where it was in 1943.

It is now proposed to dredge a deeper and wider channel from the wharves to the mouth, to short-circuit the large bend in the creek by excavation and dredging, and to construct groynes seaward from the original site of the new mouth, out beyond two fathoms of water so as to stabilise the mouth. From time to time the groynes will have to be extended in order to keep ahead of the accretion which is bound to occur at the Southern groyne. The rapidity of accretion is not known and is a matter of conjecture, but as the natural slope of the sea-bed is a very easy one, it is anticipated that accretion will be rapid.

On the whole, judging from past experience of the behaviour of sand on the East Coast, the Committee cannot help being a little dubious of the wisdom of this proposal. An expenditure of Rs. 4,70,000 is not lightly to be undertaken, especially as an unknown maintenance obligation is involved, and it has been explained to the Committee that the only object of the work is to reduce the length of carriage by lighter.

(c) Minor construction and improvements costing a little over Rs. 2 lakhs are proposed at **Negapatam** and **Cuddalore** and the Committee has no criticism to make on these proposals.

(d) **Calicut.**—Government propose to spend Rs. 9,72,000 on this port. Rs. 1,90,000 is to go to the widening of the South Pier; Rs. 6,25,000 on the construction of a new pier; Rs. 75,000 on the construction of a sea face wall north of the North Pier; Rs. 60,000 on cranes, etc.; and Rs. 22,000 on trolley lines. These proposals seem to the Committee to be sound. Calicut has a large traffic of about 600,000 tons a year, but whether this will grow or even continue, must depend to some extent on the development of Cochin.

(e) **Mangalore.**—The only substantial work proposed at this port is the reconstruction of the North Wharf at a cost of Rs. 1 lakh and this expenditure is no doubt justifiable. The Committee discussed with Government the question whether the bar at this port should be dredged down to about 14-ft. in order to give sufficient depth for the admission of small steamers of 1,500 tons. The facilities that will be created by the removal of the bar will be a great relief to the passengers moving to and from Mangalore. It will, however, involve definitely non-remunerative expenditure and will call for maintenace dredging operations. It is difficult to say whether the incurring of such expenditure will be justified by the nature and extent of the relief that it will provide for. Such work could similarly be undertaken at the Ports of Beypore (Calicut) and Cuddalore but, apart from the works themselves, maintenance dredging will be required.

(f) **Tuticorin.**—The Port Trust Board which manages the affairs of Tuticorin Port has a programme of works amounting to over Rs. 12½ lakhs. Of this amount, however, Rs. 9 lakhs are allocated to a new dry dock and accompanying buildings and the Committee is informed that it has been decided to postpone this work. The balance of over 3½ lakhs is spread over several items of wharves, jetties and passenger facilities, also a new grab dredger and several other smaller items. All these works represent normal port improvement.

(g) Other much smaller works are proposed at the minor ports of Adirampatnam, Tellicherry, Malpe, Coondapore, Hengarkotta and Calingapatam, and the Committee has no special remarks to make on them.

Financing the Works

The Madras Government representatives were asked how it is proposed to finance the works detailed above, and it was explained to the Commitee that the present proposal is to make a free grant of Rs. 43 lakhs to cover them. It appears that funds to this amount lay some years ago in the Minor Ports Fund and that about the year 1939 Government used those moneys for other purposes. Now it is suggested that the money may be re-transferred to the Minor Ports Fund and be used to carry out the improvements mentioned above.

Calicut and Tuticorin.

In the second term of reference, attention was drawn to the somewhat artificial distinction between major and minor ports. Calicut and Tuticorin emphasise the weakness of this distinction because Tuticorin has reacred a tonnage of about 500,000 tons a year and Calicut of 600,000, figures comparable with those of Vizagapatam and Chittagong and almost as large as the tonnage of Cochin. The traffic at Tuticorin consists chiefly of imports of grain, coal, cotton, cocoanuts, and exports of grain, fibre, vegetables, cotton yarn, dry fish and salt, and that at Calicut of imports of grain and manure, and exports of tea, groundnuts, coir and coffee.

These two ports serve a large hinterland and do considerable trade, and it is not perhaps a wise policy to separate them from the major ports as though they were in some way different in quality. The Committee, therefore, feels that the potentialities of these ports becoming major ports in course of time should influence the solution of the problems connected therewith.

Legal Notes

Wreck Removal in Harbour Waters

A point of considerable importance to Harbour Authorities was heard before Lord Justice Scott in the Court of Appeal in July. It concerned the issue of a writ on a foreign firm for the cost of removing the wreck of the *Brabo* sunk at the entrance to the Tyne during the war. It was promoted by the Tyne Improvement Commission against the Armament Anversois and two other defendants.

In the course of his judgment Lord Justice Scott stated that he wanted to call attention to certain aspects of British legislation about wreck removal. The position revealed by the litigation in this case, gave ground for thought. It had been stated that the expenditure incurred by the plaintiffs in the wreck removal of the *Brabo* and her cargo was about £250,000. The sinking of the *Brabo* in the plaintiff's harbour was not caused by any tortious act of her owners towards the Harbour Authority. If the owners of the ship were not guilty of any tort, neither were the owners of her cargo. Nor had the Harbour Authority done anything wrong. But their duty was to clear the port of obstructions, and that meant in this case a tremendous expense, and if they could not recover it from a third party, it was a great hardship for them.

These plain facts seemed to demand consideration by Parliament of the whole question of statutory liability for wreck removal. It might be that the national interest of keeping our harbours clear of obstructions would justify a financial policy of treating that type of expenditure as one to be borne by the national exchequer.

A further question which was involved, said Lord Justice Scott, was that of limitation of shipowners' liability, which had been dealt with by an international convention. Under Belgian law, the owners of the *Brabo* would be under no liability for the cost of removing her wreck, if she had sunk in a Belgian port or the present proceedings were taken in Belgium.

The Comite Maritime International was holding an international conference in Antwerp, on September 24th next, to reconsider the limitation convention and other matters. It would be very helpful to the attainment of uniformity in maritime law, if the conference then had the benefit of the views of those interests in this country which were affected by the aspects of public policy to which he had drawn attention as arising out of the present appeal.

The order of the court would be that the appeal was allowed, the writ and notice for service out of the jurisdiction being set aside, with costs in that court and below.

Leave to appeal to the House of Lords was granted.

Reinforced Concrete Sliding Caissons

An Article for Students and Junior Engineers

By STANLEY C. BAILEY, Assoc.M.Inst.C.E., F.G.S.

General.

SLIDING and ship caissons for closing the entrances to dry docks and locks have so far only been constructed of either wrought iron or steel; these require scraping, tarring and painting periodically, as they are liable to rust rapidly when immersed in sea water, and even the dry interiors of the air chambers will soon rust if not painted or tarred frequently.

If built of reinforced concrete, as some small ships, barges and caissons for wet basin walls have been, no painting will be necessary, and the cost of upkeep can be reduced to a minimum. They are heavier than steel built caissons and, because of the larger quantity of water displaced by the portions immersed in the tidal chambers, they require slightly more ballast to sink them in the entrance groove.

For instance, in the case of a steel constructed sliding caisson for an entrance 130-ft. wide, with vertical walls, and 50-ft. deep from the coping to the cill level, the width of the caisson being 26-ft. or 1/5th of the entrance width, its total weight will be about 1,080 tons, exclusive of ballast, or equal to 3.33 cwts. per sq. ft. of entrance area (6,490 sq. ft.) and 14.09 lbs. per cubic ft. of total volume.

To sink this in the entrance groove at an extraordinary high tide (H.W.E.T.) level, 4-ft. below the coping, would require 205 tons of cast iron ballast at the bottom and 220 tons of water ballast in the air chamber tanks, a total of 425 tons.

A reinforced concrete caisson (as shown by Figs. 1, 2 and 3), also 26-ft. wide, and for an entrance similar to that given above, will weigh without ballast about 1,463 tons, or 4.5 cwts. per sq. ft. of entrance area, and 18.71 lbs. per cub. ft. of volume, and, to sink it in the groove with 4-ft. freeboard at H.W.E.T., will require 250 tons of cast iron ballast in the bottom and 210 tons of water ballast in the air chamber, a total of 460 tons. A steel skin plate 1-in. thick will weigh 40.8 lbs. per sq. ft. and will displace 0.08 cub. ft. of water per sq. ft., while a 3-in. thick concrete skin, at 150 lbs. per cub. ft., weighs 37.5 lbs. per sq. ft. and displaces 0.25 cub. ft. per sq. ft., and a 4-in. skin = 50 lbs. sq. ft. displacing 0.33 cub. ft. per sq. ft.

Reinforced Concrete Caisson.

Figs. 1, 2 and 3 show the cross section, end view, and half longitudinal section of a proposed reinforced concrete sliding caisson for an entrance 130-ft. wide and 50-ft. deep from coping to cill, with 44-ft. depth of water at H.W.S.T. on the cill and 6-ft. freeboard and 41-ft. depth of water at H.W.N.T. The width of the caisson is 26-ft., and 28-ft. over the bearing timbers.

In the calculations to be given, an extraordinary rise of tide of 2-ft. above H.W.S.T. has been allowed for. The caisson is divided into three chambers, B, D and F (Fig. 1), by two watertight decks, E and G; the upper tidal water chamber B is 17-ft. 6-in. high, the air chamber D is 16-ft. 6-in., and the lower water chamber F is 16-ft. The air chamber contains the scuttle tanks at each end, which are each capable of holding 166 tons of water ballast, also the pumping machinery for emptying the tanks, which are filled through valves in the floor in connection with the lower water chamber.

The upper deck (A) is a fixed one, for road and railway traffic if required; it is of reinforced concrete, 7-in. to 9-in. thick, covered with 3-in. thickness of Jarrah or elm wood blocks laid in bitumen. Under this deck at each end are the trimming tanks, each capable of holding 33 tons of water supplied by the wharf mains, and required for the purpose of preventing the caisson kicking when in motion.

Deck C, over the air chamber, is 7-in. thick and is covered with 1-in. of asphalt! it is supported by beams 9-in. by 1-ft.—6-in. deep; it will be required to carry the weight of water above it, due to a head of 13-ft.—6-in., in addition to its own weight.

Deck E, of the air chamber, is of similar construction to that in deck C. This will be required to support the upward pressure of water due to a head of 30-ft., as well as the weight of water in the scuttle tanks and the weight of the pumps, etc., but these will partly counterbalance the upward water pressure.

Between decks C and E there are 9-in. × 9-in. central stanchions 10-ft. apart. Deck G, at the base of the caisson, is an open one, with the exception of a floor at each end 7-in. thick, 26-ft. wide and 15-ft. long, to carry the cast iron or concrete block ballast required to stabilise the caisson when floating. Diagonal bracing will not be necessary, as this deck has a continuous bearing against the cill. It is usually specified that when the caisson is floating and ballasted with concrete or cast iron, that there should be a freeboard of either 6-in., 9-in. or 12-in. between the top deck (C) of the air chamber and the water level, so the height of this chamber and the amount of ballast required must be arranged accordingly. The weight of the caisson and ballast required can be obtained approximately by calculation, but can only be accurately determined after the caisson has been launched and its draught obtained.

The skin of the caisson consists of 3-in. thick reinforced concrete from the top deck to the roof of the air chamber, and below that level it is 4-in. thick; the steel reinforcement will require to be in the centre of the thickness to give it sufficient concrete covering. Under the caisson, inverted steel channels are fixed, which bear on rollers attached to the floor of the groove and camber or caisson chamber; these channels should be wider than the rollers, to allow sufficient lateral movement of the caisson, so that it may press tightly against the cill and walls, the channels being turned up at the ends.

The deck handrails of steel tubes and the stanchions are all pivoted, and every alternate stanchion is extended down into the upper water chamber and terminates in a balance weight.

When the caisson is about to be pulled into the chamber, the cover over the chamber is raised vertically a few feet by power operated jacks or rams, and, as the caisson is pulled in, the tops of the handrail stanchions strike against inverted steel longitudinal channels under the cover and are depressed almost to the deck level of the caisson.

Bollards and ring bolts will be required at each end of the caisson at the deck level, and ladders on the outsides from the top deck to the roof of the air chamber. Draught figures should be painted near the stems on each side.

Timber-work.

The timber required for the clapping cill and stems of the caisson should preferably be of uncreosoted Demerara greenheart, 14-in. on the bearing surfaces × 12-in., using either butt joints or joints with short laps, bolted to the concrete beams of the caisson. Between the timber and the concrete, a thick layer of bitumen sheeting or tarred felt should be interposed.

The bolts should be 1⅛-in. diam. and galvanised, passing through holes pierced by either electric or pneumatic drills in the timber and concrete and spaced about 4-ft. apart, arranged zig-zag and a driving fit, the heads of the bolts and washers being sunk in the timber and the openings closed with hard wood plugs, the nuts with washers and grummets bearing on the concrete at the back. The fendering to the upper portions of the sides of the caisson may consist of 9-in. × 6-in. horizontal and creosoted elm, spaced a few feet apart, and fixed by Lewis bolts at 5-ft. intervals to the concrete stringers.

Reinforced Concrete Sliding Caissons—*continued*

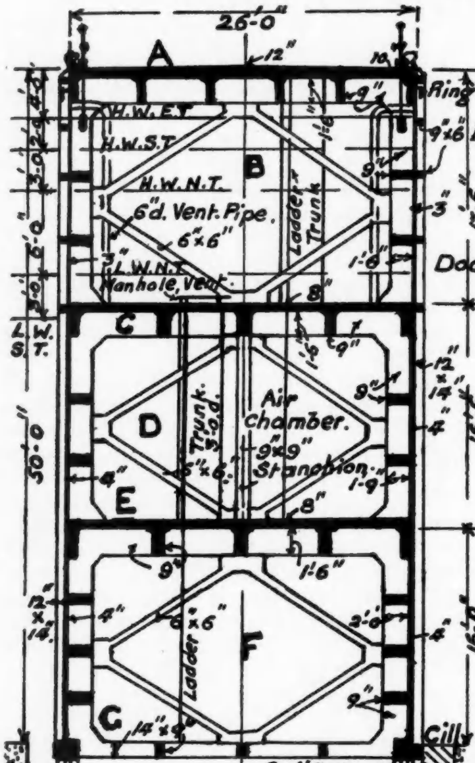


Fig. 1.

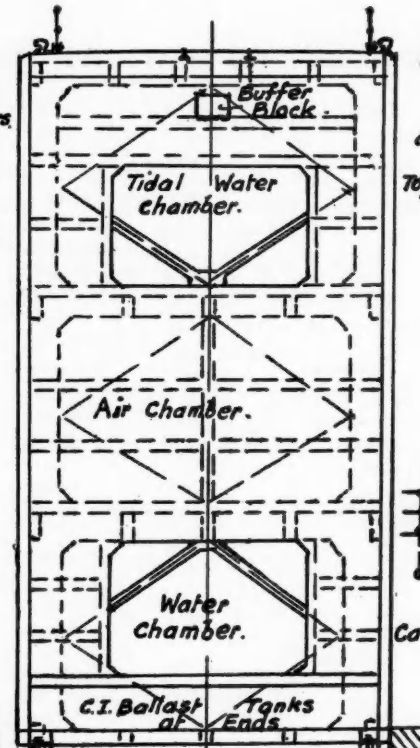


Fig. 2.

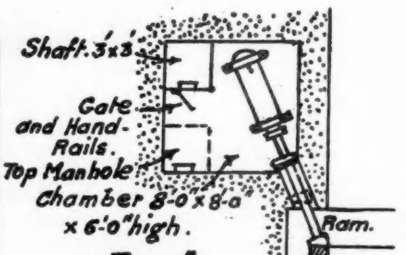


Fig. 4.

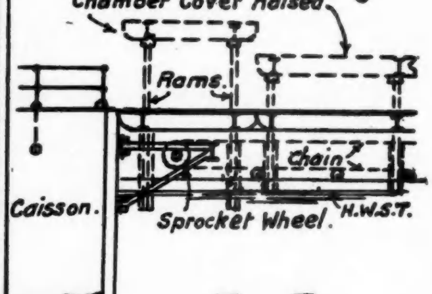


Fig. 5.

Fig. 3.

Reinforced Concrete Sliding Caissons—continued

Weights of Materials

The weights of materials are important in caissons, and, where possible, samples should be weighed before any calculations are made. For the present purpose, the weights assumed are as follows, in lbs. per cubic foot, viz.:—Greenheart timber, 70; elm, 40; jarrah, 62; asphalt, 156; reinforced concrete, 149.33; or 15 cubic feet per ton, and cast iron ballast stacked; 400 or 5.6 cub. ft. per ton. Rectangular cast iron ballast weighs 448 lbs. per cub. ft. or 5 cub. ft. per ton.

Caisson Entrance and Chamber Cover

The entrance outside the caisson is shown 130-ft. 6-in. wide in the sketches, and the groove 31-ft. wide, to allow the caisson to be installed in the entrance, or removed from the groove for repairs if required. For this purpose the caisson is pulled a few feet into the chamber, and the draw bars which are attached to brackets on the end of the caisson facing the chamber by steel pins are dismantled, the caisson is then lightened by either draining ballast from the trimming tanks, or by pumping out about 61 tons of water from the scuttle tanks in the air chamber to enable the caisson to rise about 2-ft. clear of the cill level at H.W.N.T., but more water may require to be pumped out, because after some years there may be an accumulation of mud on decks C and G, an inch thickness of which would weigh about 7 tons, allowing for its weight in water.

Before the water is drained or pumped out of the tanks, the caisson chamber cover is raised sufficiently to allow the caisson to rise, the stanchions and handrails being fastened down. The caisson chamber cover measures 140-ft. by 40-ft. wide, and will weigh about 73 lbs. per sq. ft. or a total of 178 tons, and consists of two portions, the length of 10-ft. at the outer end, and supported on 4 vertical rams weight 13 tons or 3.25 tons per ram, the remainder 130-ft. long is carried by 28 rams about 10-ft. apart longitudinally, it will weight about 165 tons or nearly 6 tons per ram. The 10-ft. front length can be raised several feet higher than the remainder, to enable the caisson to be placed in the groove, or removed if required as shown in Fig. 5, the caisson being raised so that the clearance of the keel above the cill is 2-ft.; but for normal operation of the caisson, both sections of the cover would be raised to equal heights.

The deck of the cover consists of two longitudinal beams 2-ft. deep bearing on the rams, with cross girders 2-ft. deep and 10-ft. apart, also 8 longitudinal beams 1-ft. 3-in. deep spaced about 4-ft. centres. Steel plates ½-in. thick are riveted to the top flanges of the beams and coated with bitumen applied hot on which is laid creosoted hard wood blocks 3-in. thick.

The cover over the machinery pit is a fixed one and is provided with manholes large enough to instal the machinery.

This makes a strong and light deck, and avoids the use of steel trough flooring filled with concrete which adds greatly to the weight, without increasing the strength.

A central spring buffer is provided just below coping level in the caisson groove opposite the chamber for the end of the caisson to strike against when being pushed across the entrance.

The two lines of cast steel rollers without flanges, revolving in cast steel pedestals fixed to the floors of the groove and chamber are spaced 10-ft. apart longitudinally.

The use of rollers avoids any obstruction from mud, stones, or metal, as in the case of sliding caissons without rollers, in which aprons of thick rubber sheeting at each end are required.

The bearing surfaces for the stem and cill timbers of the caisson against the walls and cill should preferably be of fine grained granite or basalt, fine axed to a smooth surface.

In some cases the surface is polished, but this is scarcely necessary.

Machinery for Operating and Chamber Cover, etc.

The type of machinery used for operating the caisson and chamber cover will depend upon the form of power available, which mav be either hydraulic, pneumatic, or electric.

Hydraulic power is usually worked at a pressure of 700 lbs. per sq. in. and pneumatic at 150 to 350 lbs. per sq. in., but may be higher.

When hydraulic or pneumatic power is used the caisson operating engines at the end of the chamber below coping level are usually of the oscillating cylinder type, geared to the sprocket wheels on the walls at the inner end of the chamber.

Electric power is applied by motors also geared to the sprocket wheels, all machinery being in duplicate.

There are similar sprocket wheels on each side of the chamber below coping level, at the outer end; these wheels are connected to those at the inner end by endless linked chains, and at the chamber end of the caisson there are strong draw bars with a cross beam at the outer ends which is attached at each end to the upper portions of the chains, the lower portions of the chains pass over rollers at intervals to prevent sagging.

Some caissons are operated by wire ropes in lieu of linked chains; there are two sets of ropes, one set is attached direct to the caisson, to pull it into the chamber, and the other to haul it across the entrance, this rope passes over pulleys at each end of the chamber, and the outer ends of the draw bars are clamped to it.

The ropes are led to a power house constructed about 15-ft. above the coping level on stanchions at the inner end of the chamber, and are operated by electrically-driven winches developing about 90 h.p. at a speed of about 25-ft. per minute, so that for an entrance 130-ft. wide, it can be opened or closed in about 5 minutes. If compressed air power is used at 75 lbs. per sq. in., the pull required to operate a caisson at 25-ft. per minute is about 35 tons.

The rams for keeping the caisson pressed against the entrance (Fig. 4) or for operating the chamber deck (Fig. 5) may be either worked by hydraulic or pneumatic pressure, or they may be pinion and rack rams, or screw jacks worked by pinions on shafts geared to electric motors.

The rams used for pressing the caisson against the entrance walls, are in lieu of wedges, to prevent any fleeting or movement of the caisson at high water, when the water in the dock is being pumped out, or if there should be a higher level of water in the dock, than outside before pumping has begun.

The rams are in chambers in the walls outside the caisson groove and are placed diagonally in plan, to butt against the stem timbers of the caisson as shown in the plans Figs. 4 and 6. The upper rams are 8-ft., and the lower ones 29-ft. 6-in. below coping, each chamber being connected by a 3-ft. square shaft with ladder.

The pumps in the air chamber may be either of the barrel and plunger type or centrifugal, operated by a Diesel engine.

Water Pressures on Caisson

The maximum lateral water pressure on the caisson when sunk in the groove at H.W.E.T. and the dock empty, for a head of 47-ft. 2-in. is

$$\frac{47\text{-ft. }2\text{-in.} \times 47\text{-ft. }2\text{-in.} \times 1\text{-ft.}}{2 \times 35} = 31.77 \text{ tons}$$

per lineal ft., which by 132-ft. 4-in. = 4,204.12 tons.

The pressure on the cill = 1.34 tons sq. ft. × 124-ft. = 166.16 tons, therefore each wall will have to bear a triangular pressure of

$$\frac{4204-166}{2} = 2{,}019 \text{ tons, neglecting decimals.}$$

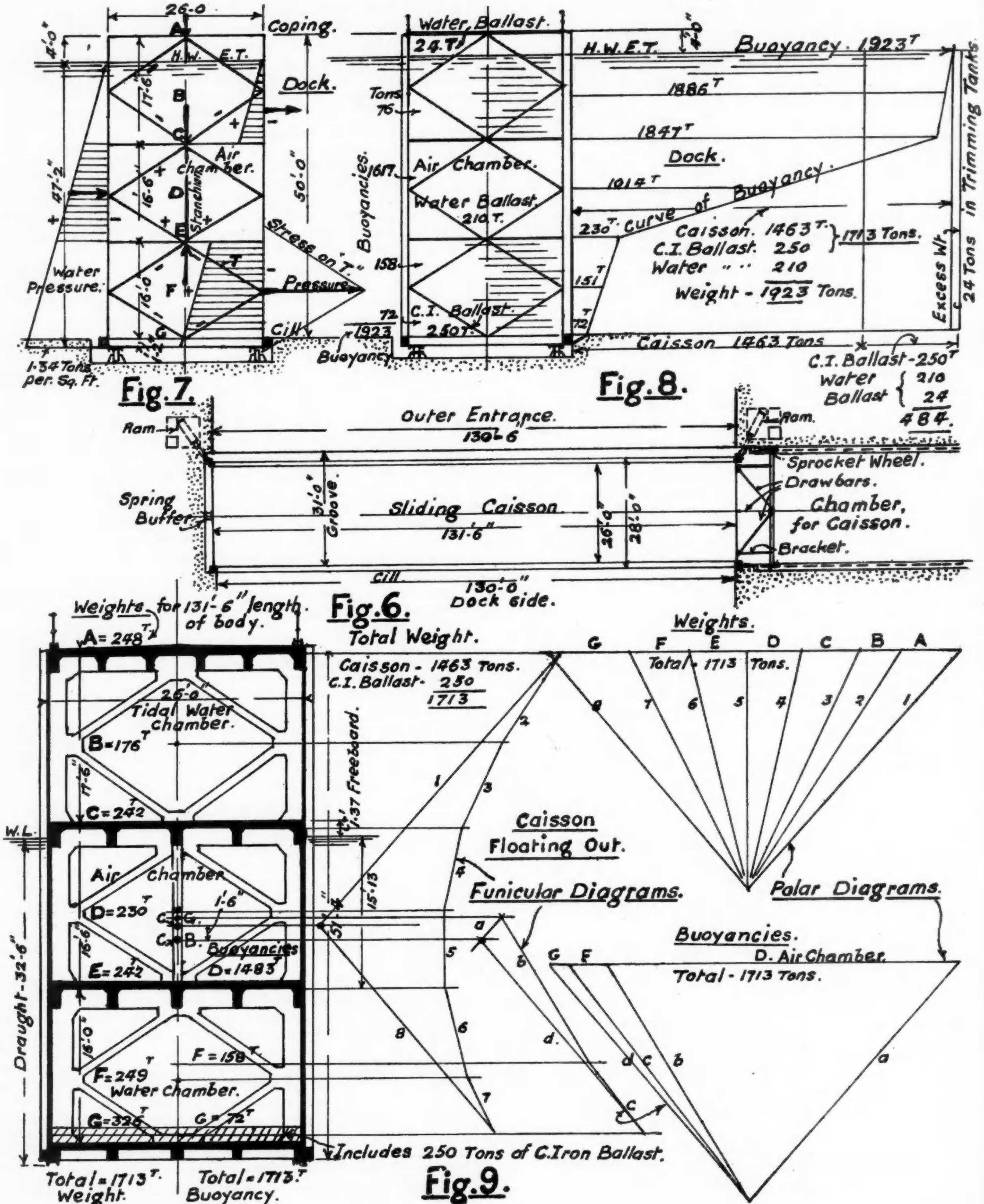
The pressure on the walls at cill level (46-ft. head) = 1.31 tons × 126-ft. = 165.06 tons or 82.53 tons per sq. ft. on each wall, and as the bearing area of the timber is 14-in. × 12-in., the pressure will be 71.1 tons per sq. ft.

The decks form the main girders of the caisson, the decks being the webs, and the skin concrete the flanges.

The lateral water pressure on the top deck A = 86 tons, on deck C it is 807.2 tons, on deck E it is 1,920.1 tons, and on the bottom framing G, it is 1,390.78 tons, a total of 4,204 tons.

Fig. 7 shows the distribution of the lateral water pressures on the caisson. The weight of water on deck C over the air chamber due to a head of 13-ft. 6-in., is 1,286.7 tons, and the upward pressure under deck E, forming the floor of the air chamber, and under a head of 30-ft. will be 2,840.5 tons.

Reinforced Concrete Sliding Caissons—continued



Reinforced Concrete Sliding Caissons—continued

Calculations for Strength of Caisson

The decks should be calculated for the lateral loads, as beams with free ends, the B.M. at the centre being $\frac{W.L.}{8}$, the width of the skin flanges should be taken at half the distance between the decks on each side of the decks forming the webs, and the moment of inertia (I) of the deck, longitudinal beams and skin, obtained for the cross section, the tensile stress = $\frac{M.y.}{I}$ and the compression = $\frac{M.x.}{I}$ where y and x are the distances from the neutral axis to the C.G. of the skin flanges.

The top deck (A) will probably be required to carry heavy motor lorries and possibly a railway, these loads must be determined, the total dead load will be 162 lbs. per sq. ft.

The cross beams 10-ft. apart should be calculated as single spans of 22-ft. 6-in., to avoid the diagonal ties in chamber B, being treated as struts.

The dead weight of dock C over the air chamber is 159 lbs. per sq. ft. + 864 lbs. of water pressure, a total of 1,023 lbs. per sq. ft.; the cross beams are divided into two lengths by the central stanchions

In deck E at the bottom of the air chamber, the dead load is also 159 lbs. per sq. ft., less the upward water pressure in chamber F of 1,920 lbs. = 1,761 lbs. sq. ft., the cross beams being in two lengths.

During the construction of the caisson the cross beams and longitudinals will have to carry the weight of the deck E, and the cross beams will have in addition the loads from the central columns supporting deck C, so they should be calculated as single spans for this purpose with tensile reinforcement at the bottom of the beams; but when sunk the conditions are reversed, and they may be treated as two spans with steel reinforcement at the top also.

All the deck beams, longitudinal stringers on the sides of the caisson, and the stanchions, may be calculated as fixed beams for a B.M. of $\frac{W.L.}{24}$ at the centre and $\frac{W.L.}{12}$ at the supports. The stanchions will be required to act as beams in addition to their vertical loads, which will be considerable.

There will be no pressure on the lower stanchions in chamber F when the caisson is floating, they will then be in tension, as all below the bottom of the air chamber is suspended and the weight of this portion is 575 tons, including the ballast, less the buoyancy of 130 tons, leaves 445 tons on a skin and stanchion area of 20,500 sq. in., or a tension of 48.6 lbs. per sq. in.

With regard to the lateral water pressure on the concrete skins at H.W.E.T. at the top of the air chamber D the pressure is 13-ft. 6-in. by 1-ft. by 1-ft. × 64 lbs. = 864 lbs. or 0.385 tons per sq. ft.; at the bottom of the air chamber it is 1920 lbs. = 0.857 tons per sq. ft. and at the cill level 2944 lbs. = 1.314 tons sq. ft.

The main steel tensile reinforcement should be vertical in the centre of the thickness and the B.M. will be = $\frac{W.L.}{8}$. The distribution rods $\frac{1}{4}$-in. diameter are horizontal and 12-in. apart.

Taking the lowest panel of the 4-in. thick skin, the average water pressure on a clear span of 3-ft. = 1.25 by 3-ft. = 3.75 tons = W. and the area of steel required per lin. ft. = $\frac{W.L.}{8. D.S.}$ = $\frac{3.75 \text{ by } 2240 \text{ by 3-ft. by 12-in.}}{8 \text{ by 12-in. by } 16{,}800}$ = 1.12 sq. in., and 2 steel rods $\frac{7}{8}$-in. diameter = 0.6 by 2 = 1.2 sq. in.; D is the depth from the surface of the concrete to the steel, and S = safe stress on the steel in lbs. per sq. in.

The 6-in. by 6-in. diagonal ties in the chambers are mainly in tension, except those on the outer side of the air chamber D which comes under lateral water pressure.

Weight of Caisson and Curve of Buoyancy

The weight of the caisson, including 250 tons of cast-iron ballast = 1,713 tons, and its buoyancy when sunk in the groove at H.W.E.T. is 1,923 tons, so that 210 tons of water ballast will be required in the scuttling tanks at the ends of the air chamber; the caisson will then be in equilibrium; to keep the caisson bearing on the rollers, and to prevent it kicking while being operated, an extra 24 tons of water is put in the two trimming tanks below the top deck, bringing the total weight up to 1,947 tons.

Fig. 8 shows the curve of buoyancy for these conditions, with H.W. on each side of the caisson.

Friction of Caisson on Walls and Cill

With regard to the friction of the caisson on the bearing faces of the walls and cill; the total pressure is 4,204 tons at H.W.E.T. when the caisson is sunk in the groove, and the dock is empty.

The co-efficient of sliding friction for timber bearing on wet stone is about 0.38 to 0.406, but may be so high as 0.6, therefore 4,204 tons by 0.38 = 1,597.5 tons, which will be the friction, and the pressure necessary to raise the caisson.

The total bearing area is 222-ft. by 1-ft. 2-in. = 259 sq. ft., the friction therefore amounts to 6.1 tons per sq. ft.

The dock being empty, the buoyancy of the air chamber will be increased, due to its standing out 1-ft. (the thickness of the stem timbers) from the walls, this will amount to 1,678 tons in lieu of 1,617 tons, when there is water on each side. There will also be increases in the buoyancies of the upper and lower water chambers for the same reason, and deduction for the fendering on the dock side.

The total buoyancy will be about 2,090 tons, in lieu of 1,923 tons, an excess of 167 tons; and as the weight of the caisson is 1,713 tons, therefore 2,090 — 1,713 = 377 tons of water ballast in lieu of 210 tons, would be required in the tanks to keep the caisson sunk, if there was no friction.

As the excess buoyancy is 167 tons, and the least friction amounts to 1,597.5 tons, there will be an excess of friction over the additional buoyancy of 1,430.5 tons, so there will be no need to increase the water ballast in the tanks.

Centres of Gravity and Buoyancy

The weights and buoyancies of the various portions of the caisson having been calculated so accurately as possible, the centres of gravity (C.G.) and buoyancy (C.B.) can be found graphically as shown in Fig. 9, or obtained by calculation, the moments (M) of the weights (W) and buoyancies being taken from a datum line at or below the keel of the caisson, then the height (X) of the C.G. above the datum line = $\frac{M_1 + M_2 + M_3}{W_1 + W_2 + W_3}$, etc., the C.B. being obtained in a similar manner.

The C.G. should be so close to the C.B. as possible, but will probably be above the latter; in the present case the C.G. is about 18-in. above the C.B. when the caisson is floating with 1.37-ft. freeboard to the top of the air chamber, and loaded with 250 tons of cast-iron ballast, and the draught will be 32-ft. 6-in., so that at H.W.S.T. with 44-ft. of water over the cill, there will be a clearance of 11.5-ft.; and at L.W.S.T. and 41-ft. depth of water, the clearance will be 8.5-ft. for the tidal rises shown in Figs. 1 and 3.

These are suitable conditions if the caisson is required to be towed at sea from the works where it has been constructed to the dock site, but for placing it in the entrance groove, water ballast will be added until the keel is about 2-ft. above the level of the cill.

Launching Caisson

The caisson may be constructed in either a dry dock or a floating dock if available, or may be built in the dock under construction for which it is intended, so soon as a portion of the floor is completed. If built on a slipway, its launching weight without ballast will be about 1,463 tons or 11.08 tons per lin. ft. and 5.5 tons per lin. ft. on each sliding way, and it will float with a draught of

Reinforced Concrete Sliding Caissons—continued

30-ft. 6-in., the water level being 3-ft. 6-in. below the top of the air chamber.

Load on Rollers

The load on the rollers at 10-ft. centres longitudinally in the groove and chamber floor, when the caisson is bearing on 28 rollers across the entrance at H.W.E.T. will be about 1,947 tons with all ballast on board, less the buoyancy of 1,923 tons = 24 tons, which is the weight of water in the trimming tanks, or 0.85 tons per roller; but at L.W.S.T. for the tides shown 32-ft. over the cill, the buoyancy will be reduced to 1,750 tons, therefore the load on the rollers will amount to 197 tons, or 7 tons per roller. The actual loads on swing bridge solid cast steel rollers, that have been constructed varies from 1.2 to 1.96 tons per inch width of rollers, and 2 tons may be safely taken, therefore for a 4-in. width the safe load will be 8 tons.

There are several empirical formulæ for calculating the safe load on cast steel wheels, such as $P = \frac{3}{8}$ D.T., in which P = safe load in tons, D = diam. in inches and T = width of tread in inches, therefore $P = \frac{3}{8}$ by 12-in. by 4-in. = 18 tons safe. Also P = 600 D.T. ∴ 600 by 12-in. by 4-in. = 12.8 tons safe in which P is in pounds.

From tests made on three travelling crane wheels of cast steel with forged steel tyres, 30-in. to 36-in. diam. and having treads of 5-in. to 6-in. width, with central flanges, the maximum test loads sustained were 9.64, 7.33 and 7.82 tons; an average of 8.26 tons per inch width of tread; the working loads of these wheels were 5.73, 6.33 and 5.73 tons respectively, an average of 5.93 tons per inch tread.

At 6 tons per inch safe load, the formula would be P = 448 D.T. in lbs. and for the caisson rollers P = 448 by 12-in. by 4-in. = 9.6 tons safe load.

Another formula gives $P = K.T. \sqrt{D}$. in which P is in tons. K = 0.55 when cold rolling of the rails is not allowed, and equals 1.62 when it is permissible; the safe load for the caisson rollers by this formula would be P = 0.55 by 4-in. by $\sqrt{12\text{-in.}}$ =7.61 tons.

It is important that the tread should be the actual bearing width, the bearing surfaces of the rollers and the runners or rails should be flat; the bearing surfaces of railway rails are rounded, and the wheels have coned tyres, so the actual bearing surfaces are small, but the maximum driving wheel loads on locomotives seldom exceed 10 tons.

The bearings on the cast steel pedestals for the roller shafts should be of phosphor bronze or hard gun-metal.

Proportions of Concrete

The concrete throughout the caisson should preferably be in the proportion by measure of 1 part of cement, 1½ sand, and 3 of gravel or broken stone up to ¾-in. size. With cement at 100 lbs. weight per cub. ft., this is equivalent to 800 lbs. of cement to 12 cub. ft. of sand, and 24 cub. ft. of gravel.

Publications Received

Materials Handling Equipment, by Mathew W. Potts, pp. 172 with illustrations, price 17/6 net. Published by Sir Isaac Pitman & Sons, Ltd., London.

This practical book by a widely-experience American author is devoted to defining, describing and presenting the application of a number of standard types of materials-handling equipment. It is based on specific information that will not change materially, although possible mechanical improvements may be made to the apparatus described.

The author deals with standard types of equipment rather than the different items of various manufacturers, and treats the fundamentals of materials-handling rather than specialised applications and technical details. All engineers and executives concerned with handling large quantities of material, as well as students, will find the book of great value and interest.

British Standard Specification for Low Heat Cement.

This new British Standard Specification covers a type of Portland Cement intended for use in structures such as dams, where large masses of concrete have to be placed, and aims at overcoming some of the difficulties met with if ordinary Portland Cement is used for this purpose.

For many years, engineers have recognised that the major cause of shrinkage cracking in large masses of concrete is the high temperature generated within the mass during the hardening period and the consequent contraction on cooling. It has been found that in dams of moderate size, e.g., 50 to 150-ft. high, laid at normal rates, the temperature of the concrete may rise 50° to 80° F, after being laid, the maximum temperature occurring after one or two months or even later in the case of very large dams. Similar temperature rises occur when bridge abutments, massive retaining walls, piers and slabs, etc., are being built.

This problem has been studied by Sub-Committees set up by the International and British Committees on large dams and the experience gained from investigations in this country and abroad had led to the preparation of this specification which covers a Portland Cement with a reduced heat of hydration as a solution to the problem.

The reduction in the heat of hydration, as compared with ordinary Portland Cement (B.S. 12 : 1940) has been achieved by fine-grinding the cement, which also has the effect of reducing the tendency of a concrete mix to segregate and the consequent separation of water at its surface, and by a reduction in the maximum permissible lime content. These changes do not affect the ultimate strength of the cement, though the rate of strength development is appreciably lower than in the case of ordinary Portland Cement.

The Specification defines the methods to be used in selecting samples for testing and the appropriate tests for fineness, chemical composition, strength setting time, roundness and heat of hydration. The test for fineness is to be carried out by the determination of the surface area per unit weight of the sample by means of a permeability cell connected to a manometer and flowmeter, as it has been found that the conventional sieve tests give no indication of the size of the finer particles. The necessary apparatus and method of operation are described in detail.

The strength of the cement is to be measured by compressive strength tests on mortar cubes compacted by means of a vibrating machine. The tensile strength test on mortar briquettes used for ordinary Portland Cement is eliminated from this Specification.

Copies of this Specification No. B.S. 1370 : 1947, may be obtained from the British Standards Institution, 28, Victoria Street, London, S.W.1., price 3/6 net, post free.